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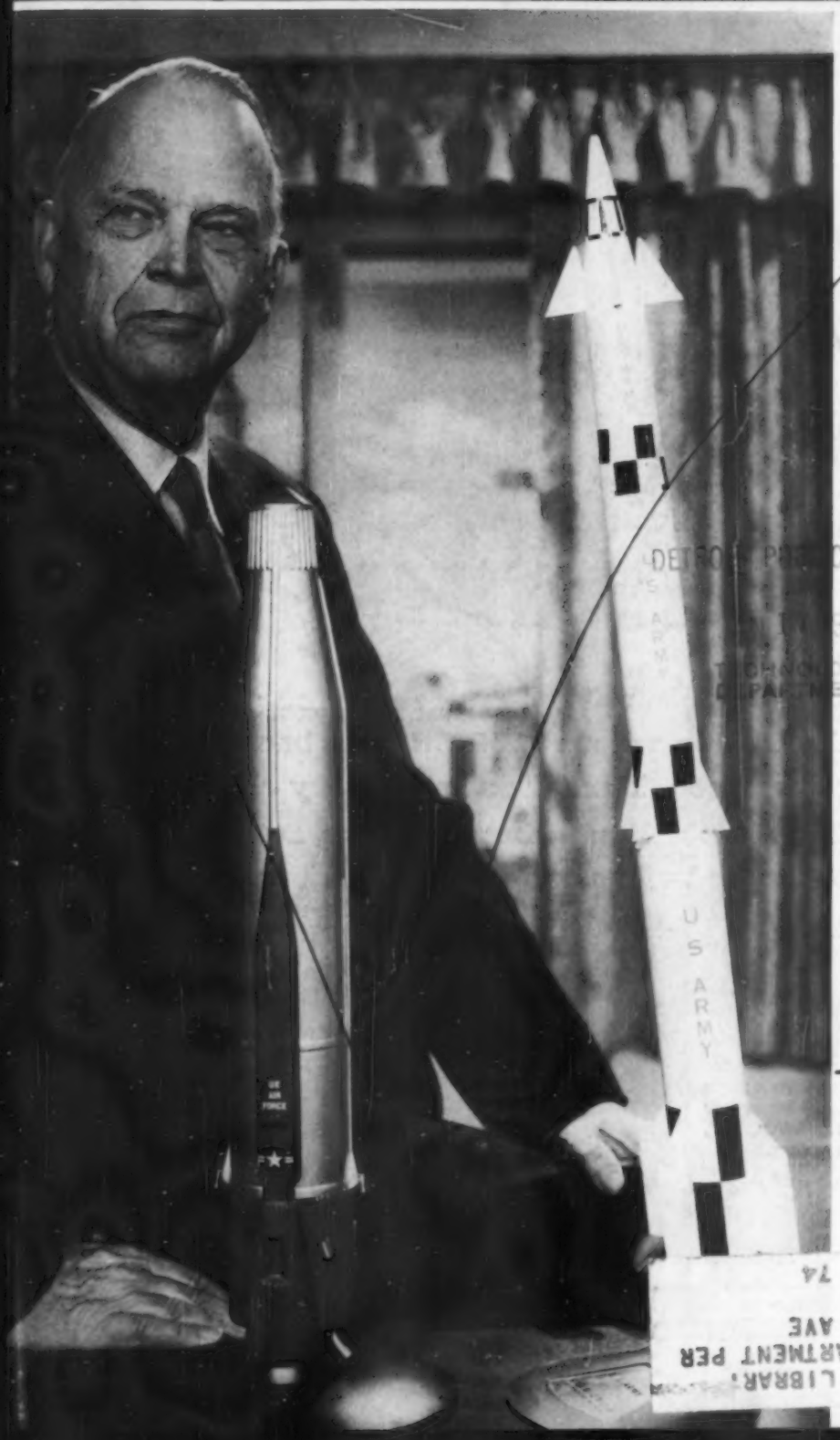

JFK Pushes U.S. Space Shake-up

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Senator Kerr: 'Now we've got the ball.'

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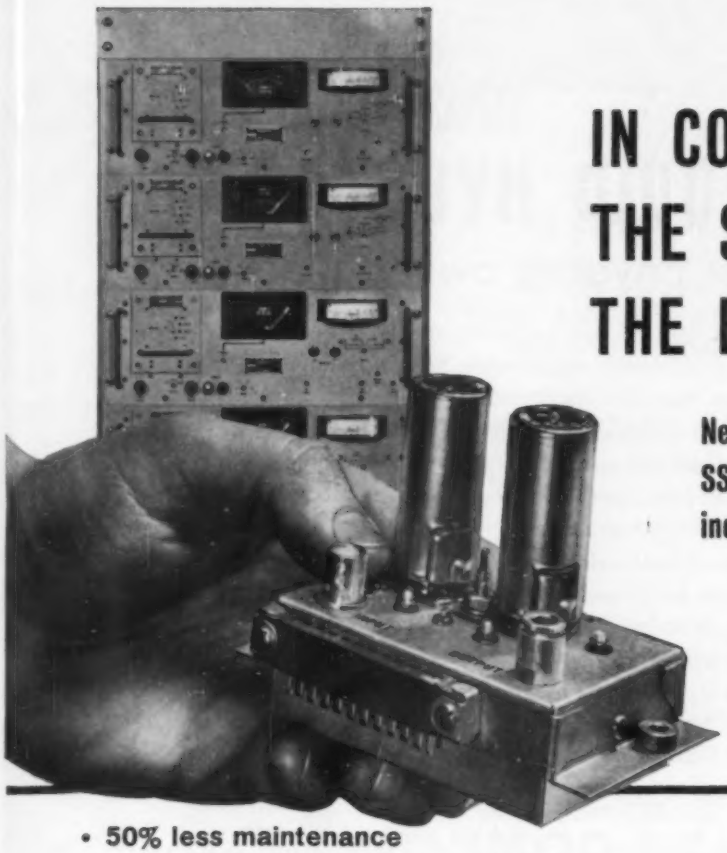

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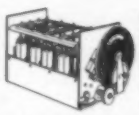

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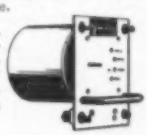

HF Crystal Oscillator Module. Stability: 1 in 10^8 per month. Capacity is four crystals; designed for HC-6/U metal or glass crystal holders. Oven temp. varies less than ±0.01°C.

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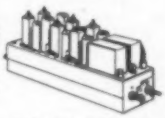

IF Module. Allows simultaneous reception of upper and lower sideband, independent AGC control of upper and lower sideband.

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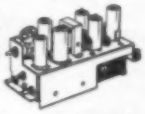

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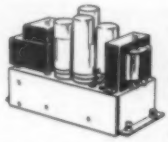

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missiles and rockets

Volume 8, No. 3 January 16, 1961

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THE COVER

Sen. Robert S. Kerr (D-Okla.), newly named chairman of the Senate Space Committee, is a key figure in President-elect Kennedy's plans to intensify space effort. See p. 11.

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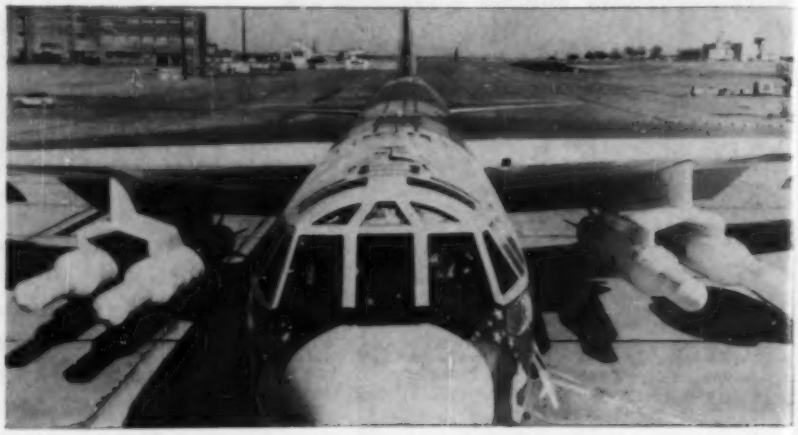
The Missile/Space Week

2nd Hard Minuteman Base

The Air Force has designated Ellsworth AFB, Rapid City, S.D. the nation's second hardened *Minuteman* base and is considering putting a third at Pease AFB, Portsmouth, New Hampshire.

Like the first hardened base at Malmstrom AFB, Montana, the base will provide support for a wing, consisting of three squadrons. Air Force plans call for 150 missiles in the three squadrons. The number of units in the mobile *Minuteman* wing headquartered at Hill AFB, Utah, has not been disclosed.

Soil borings are being made at Pease to determine whether there are enough good sites for underground facilities, but it will take several months to select locations, the Air Force said.



Dyna-Soar Mated to B-52

B-52H BOMBER at Boeing's Wichita, Kan. plant carries for first time test models of Douglas Skybolt ALBM. Compatibility tests were begun this last week.

Polaris: One Up, One Down

The Navy scored a big advance and a small set back this last week in two Lockheed *Polaris* launchings at Cape Canaveral.

An A2 R&D *Polaris*—the *Polaris II*—ripped from a surface pad and roared 1600 statute miles down the Atlantic Missile Range. It impacted only 125 miles short of the eventual range of the operational *Polaris II*.

The 31-ft. *Polaris II* is three feet longer than the operational *Polaris I* already deployed aboard two nuclear-powered submarines. Range of *Polaris I* is nearly 1400 statute miles.

The Robert E. Lee—third sub of the *Polaris* fleet—resumed its submerged test launchings of *Polaris I's* off the Cape a day after the successful A2 shot.

The *Polaris*, launched from about 60 feet beneath the surface of the Atlantic, broke the water and appeared to be on its way when a malfunction developed in the first stage. The range safety officer destroyed the missile.

The Robert E. Lee successfully launched a *Polaris* while submerged last December. It is expected to attempt to launch one more before going on station.

Strike Help Coming

Hearings will begin shortly on costly wildcat strikes which have caused severe slippage in the *Atlas* and *Titan* base programs.

The Senate investigations committee, headed by Chairman John L. McClellan (D-Ark.), has "authorized

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a full-scale investigation" into work stoppages at Cape Canaveral and other major missile bases.

Sen. McClellan said preliminary inquiries indicate a possible serious blow to the position of the United States and a waste of millions of dollars.

NORAD Seeks Shelter

The Defense Department is pushing to move the nation's Air Defense Command headquarters underground to safeguard it from enemy missile attack.

Defense Secretary Thomas S. Gates has asked the appropriations committees of the House and Senate to free $8.5 million already earmarked for the project. It would go to excavate Cheyenne Mountain near Colorado Springs, for new NORAD headquarters.

Some $1.5 million has already gone to building a road and surveying the area. Congress originally had appropriated $10 million for the project, but the Joint Chiefs of Staff had recommended abandoning it at one time.

Additional funds will be needed for equipment.

Cannon Sees SAC Demise

Rep. Clarence Cannon (D-Mo.), chairman of the powerful House Appropriations Committee, contended this last week that the time for the Strategic Air Command as America's chief deterrent force is "running out."

He told the House: "Only the nuclear-powered missile-firing submarine can take over the task of the Strategic Air Command when obsolescence overtakes it in the inevitable development of Russian technology."

Dyna-Soar Progresses

Eleven companies attended a Boeing Airplane Co. bidder's conference on requirements for the *Dyna-Soar* test-instrumentation subsystem. Boeing will award the subcontract sometime in the early spring.

Minneapolis-Honeywell has emerged winner of a subcontract totaling more than $2 million for *Dyna-Soar* flight control electronics design, development and production. Flight tests on the space glider are expected to begin in 1963.

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Said Isaac Newton:

"Every particle of matter attracts every other particle with a force directly proportional to the product of their masses and inversely proportional to the square of the distances between them."

Until recently, the thrust which propelled rocket vehicles into their coast phase, prior to orbiting, was provided by booster stages. The fuel carried by the satellite stage was used only to inject itself into orbit.

Now, however, a scientist at Lockheed Missiles and Space Division has evolved a Dual Burning Propulsion System which allows higher orbits and heavier payloads. With this system, the satellite vehicle fires immediately after the last booster stage burns out, thus augmenting the begin-coast speed. Later the satellite stage is re-started to provide orbit injection.

An even more recent development by Lockheed is a triple-burning satellite stage. This will permit a precise 24-hour equatorial orbit, even though the vehicle is launched a considerable distance from the equator.

These principles have made possible the early development of the MIDAS satellite. Moreover, they substantially increase the altitude and payload of the DISCOVERER and SAMOS satellites. Lockheed, Systems Manager for these programs and for the POLARIS FBM, is pursuing even more advanced research and development projects. As a result, there are ever-widening opportunities for creative engineers and scientists in their chosen fields.

Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-15F, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required.

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The Countdown

WASHINGTON

Gap in the Space Council

Military men are looking rather questioningly at plans to beef up President-elect Kennedy's National Space Council. The group, as presently constituted, is entirely civilian. Presumably it will remain that way. What the military men are wondering: How can the Council act as a really effective advisory body if the services are not represented other than by the (civilian) Secretary of Defense? Will this lead to a "gap" in the pursuit of strategic space systems?

Watch the Russians

Speculation that the Soviets will carry through with a rumored Inauguration Day space spectacular is being heightened by the deployment of three Russian missile tracking ships in the Pacific. They appear to be headed for the same area about 1000 miles southwest of Hawaii where previous Soviet missiles have impacted. Manned orbital shot is expected to be next on the Kremlin calendar.

Slipped Chimp

That *Mercury-Redstone* chimp shot tentatively set for a few days before Kennedy's inauguration has now slipped to the week of Jan. 22. There also is more delay in the *Mercury-Atlas* series while NASA attempts to fix a problem in capsule mating which apparently has caused two failures. (see p. 13).

Kennedy Must: Big Boosters

Look for a major push by the Kennedy Administration to develop big booster rockets. More money may be placed down the line on *Saturn*, the *F-1*, *Titan II* and *Atlas G* as well as nuclear engine development, like the atomic pulse *Orion*. The big problem facing the new administration is to obtain a large payload capability as soon as possible.

Space on the Hill

Hearings before both the Senate and House Space Committees are expected to begin quickly as soon as President-elect Kennedy takes office. Both groups will conduct broad reviews of the U.S. space program to date and where space experts think it should be headed. However, first order of business before the Senate Committee will unquestionably be confirmation of the appointment of the new NASA Administrator.

NASA vs. Pentagon

One of the hottest topics at the forthcoming hearings is certain to be the future roles of the Pentagon and NASA in space. A number of key congressmen such as Chairman Brooks of the House Space Committee want to see both roles expanded. However, others question that it is possible to expand both significantly without gross duplication.

Dr. York on the New Frontier

Intra-Pentagon strategists consider that one of the more interesting and possibly somewhat depressing deployments on the New Frontier is the retention at least temporarily, of Herbert York as Pentagon R&D Director. Many proposals already stopped at York's desk were being refurbished for presentation to his expected successor. Now they are being put back in the files for a more propitious day.

Wanted: Fast Decisions

Sources close to the new Defense Department top command say that one of the early innovations will be a drive for fast decision-making. The question being asked is how decisions can ever be made faster as long as the number of decision-makers keeps increasing. Faster decision-makers, maybe?

INDUSTRY

Nike-H Production Line Ends

Western Electric has delivered the last *Nike-Hercules* system on its production line to the Army. However, production of radar conversion kits for the *Advanced Nike-Hercules* is continuing. As system production ended, the Army begain deploying another 100 sets of *Nike-Hercules* equipment and more than 50 *Nike-Ajax* sets overseas.

Protecting Contractors

Once again DOD is asking Congress to permit indemnification of contractors against unusual hazards encountered in production and construction projects. Legislation is now considered mandatory as more missile programs move into production phase. Coverage would be similar to that now in force under R&D contracts.

Eagle Flight Test Year Away

Latest progress report in the Navy's Super-secret and radically new *Eagle* air-to-air missile puts the first flight test about one year from now. Question of what plane it will be used on is still up in the air—if a plan to stop development of the specially configured Missileer goes through.

Front Office

Both Washington State senators contend the FY '62 Eisenhower budget has $1.2 billion in it earmarked for military projects involving Boeing Airplane Co. . . . Martin Co. stockholders have okayed a 2-for-1 stock split . . . B-70's revival is creating a recruiting stir.

INTERNATIONAL

Nod for T-Bird

Word is out that the British defense Ministry has given the Army's *Thunderbird* air defense missile a production go-ahead over the RAF's *Bloodhound*. Reason: the *T-bird* (made by English Electric) has greater mobility.

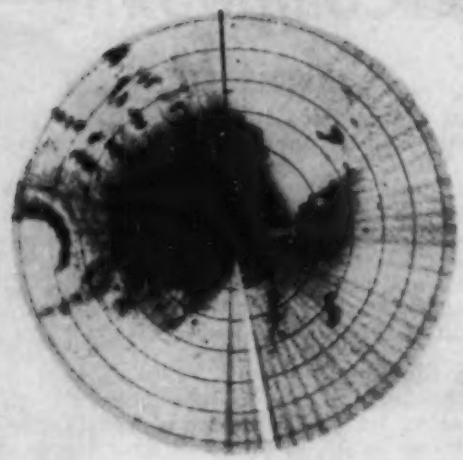
Deaf Ear to Talking Satellites

The British appear to be taking a go-slow attitude to dropping any of their pounds in developing a communications satellite. Maj. Gen. L. de M. Thuiller, leader of a recent fact-finding team that discussed communications satellites proposals in the United States, is understood to have reported to his government that commercial communications satellites appear to him to be 15 to 20 years away. Interest is reported to have cooled considerably.

Joint Rocket Production

Stages for the British *Jaguar* three-stage rocket are being produced at opposite ends of the earth. RAE, Farnborough, is turning out the first stage of the 40-foot rocket. The Australian Department of Supply is turning out the second and third.

Filming spots on the sun



or dots on the screen

"what's" with a gun

or plots on the scene

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Space Shake-up Coming

DOD-NASA programs being revamped

by James Baar

A SWEEPING SHAKE-UP of U.S. space programs—both military and civilian—and the organizations directing them is now expected within 90 days after the Kennedy Administration takes office Jan. 20.

The shake-up will be aimed at meeting the Soviet challenge in space to America's military security and world position.

The changes will be guided and monitored by the revived National Space Council under the chairmanship of Vice President-elect Lyndon B. Johnson.

The direction that the new Administration is planning to take was outlined to a considerable extent this last week in the "preliminary" space report by an Ad Hoc Committee to President-elect Kennedy. (See below.)

Kennedy, Johnson and some of their key advisers were understood to have been favorably impressed with the committee's recommendations, which included calling for the redefining of U.S. space program objectives—and possibly a single military space command.

Sen. Robert S. Kerr (D-Okla.), newly named chairman of the Senate Space Committee, called the space report "very constructive." He predicted that a "vigorous" overall space program would be developed by the Administration "to set the pace we need to set and then maintain it."

Rep. Overton Brooks (D-La.), chairman of the House Space Committee, called the report "an encouraging document that points the way to a more progressive and advanced space program."

Both congressional committees will play a major role in a general review of current U.S. space efforts recommended by the space report. However, a number of developments indicated that the Administration will use the Senate Committee as its main sounding board and investigative arm for determining where to place its space bets.

• **Money matters later**—The nine-member Ad Hoc Committee—headed by Jerome B. Wiesner, director of MIT's Electronics Research Lab—touched only lightly on the delicate subject of money. The reason appears to be the logical idea that it is difficult to put a price tag on a program until its contents have been determined.

Kerr, who was with Kennedy and Johnson when the committee made its report, expressed this attitude later.

"You can't buy a space program," he said in an interview. "No mercantile establishment on earth carries one as its stock in trade. You have to develop a space program. Once you have done that, it is a lot easier to get the money to pay for it."

Kerr said that he would not know whether more money beyond current spending would be needed until current programs are reviewed. He indicated, as have others in the new administration, that present spending on space programs—which is nearing $2 billion a year—might go much farther if spent differently.

However, when asked what he would think of a proposal to double U.S. spending on space, Kerr said: "I would be neither shocked nor mesmerized. If our analysis showed that we needed to spend that much for the security of the country, I would favor it."

Brooks said he favors increasing the FY '62 budget for NASA alone to at least $1.5 billion.

Highlights of Space Report

FINDINGS

• Our review of the United States' space program has disclosed a number of organizational and management deficiencies as well as problems of staffing and direction which should receive prompt attention from the new Administration. These include serious problems within NASA, within the military establishment, and at the executive and other policy-making levels of government.

• Neither NASA as presently operated nor the fractionated military space program nor the long dormant Space Council have been adequate to meet the challenge that the Soviet thrust into space has posed to our military security and to our position of leadership in the world.

• The nation's ballistic missile program is lagging. The development of the missiles and of the associated control systems, the base construction and missile procurement must all be accelerated if we are to have the secure missile deterrent force soon that the country has been led to expect.

• Because of our lag in the development of large boosters, it is very unlikely that we shall be first in placing a man into orbit around the earth. . . . The ultimate goal of this kind of endeavor would of course be an actual landing of man on the moon or a planet. It is not possible to accomplish such a mission with any vehicles that are presently under development.

• . . . The rapid development of boosters with a greater weight-lifting capacity is a matter of national urgency. . . . The present *Mercury* program, based on the *Atlas*, is marginal.

RECOMMENDATIONS

• Make the Space Council an effective agency for managing the national space program.

• Establish a single responsibility with the military establishments for managing the military portion of the space program.

• Provide a vigorous, imaginative, and technically competent top management for NASA, including:

(a) Administrator and deputy administrator.

(b) A technical director for propulsion and vehicles; a technical director for the scientific program; a technical director for the non-military space applications; a technical director for aerodynamic and aircraft programs.

• Review the national space program and redefine the objectives in view of the experience gained during the past two years. Particular attention should be given the booster program, manned space flight, the military uses of space, and the application of space technology of the civilian activities of the country.

• Establish the organizational machinery within the government to administer an industry-government civilian space program.

The present NASA budget is slightly over $900 million, and the Eisenhower budget for NASA for FY '62 provides only moderate increases. Military spending for space programs currently is running under $1 billion.

• **Hard on NASA**—The Ad Hoc Committee concentrated primarily on U.S. space goals and organization. In both cases, it implied almost as it said outright.

It repeatedly urged that U.S. space goals be reassessed thoroughly and promptly—"particularly in regard to man-in-space, space, science and exploration, and non-military applications of space in order to have a proper division of effort."

The obvious implication was that the committee felt that present goals are poor ones and that the present division of effort between the Pentagon and NASA should be readjusted. What the readjustment should be was not made clear.

However, the report repeatedly criticized NASA operations. It said among other things that NASA's main program, *Mercury* was marginal; that NASA "channeled into NASA-operated facilities . . . too large a fraction" of its program; that it gave "little attention" to aeronautics R&D, which perhaps should go to another agency.

Finally, the report clearly implied in its recommendations that NASA lacked "vigorous, imaginative and technically competent top management."

• **Accent on positive**—The committee laid particular stress on the scientific and commercial gains to be expected from space programs.

"The government through NASA or the Department of Defense should make available the required physical facilities as well as any extraordinary financial support required to make the undertakings successful," it said. "Organizational machinery is needed with the Executive Branch of the Government to carry out this kind of civilian space program."

But of all of the committee's recommendations and criticisms possibly one of the most cutting was reserved for scientific participation in U.S. space programs. The committee said:

"In addition to the difficulties and delays which the program has endured because of the lack of sufficient planning and direction, it has also been handicapped because too few of the country's outstanding scientists and engineers have been deeply committed to the development and research programs in the space field."

The committee besides Wiesner included: Physics Prof. Edward Purcell of Harvard; Chemistry Prof. Donald Hornig of Princeton; Physics Prof. Bruno B. Rossi of MIT; Edwin H. Land, president of Polaroid; Trevor Gardner, president of Hycon Manufacturing Co. and former assistant Air Force Secretary for R&D; Kenneth E. BeLieu, staff director of the Senate Space Committee; Max Lehrer, the committee's assistant staff director; and Harry J. Waters assistant to the President of Polaroid.

• **Kerr sums up**—Much of the heart of what the committee said in its report was brought into improved focus by comments made by Kerr after he was officially named chairman of the Space Committee to succeed Johnson.

The sharp-witted Oklahoma senator leaned back in his desk chair and said:

"We've said some pretty strong things about the Administration's space program. Now we've got the ball. We must move vigorously and actively to analyze and appraise and improve the space program or put ourselves in the position of acquiescing."

Kerr smiled.

"Today the space program is mainly the program of the Eisenhower Administration," he said. "We have a limited time to demonstrate our purpose and ability to improve it and develop a program of our own. We intend to do it."

Then the new chairman offered an insight into his view of where the United States would go in space. He said:

–"First we will explore the space immediately adjacent to the earth including the moon, Mars, Venus and Mercury."

–"Second we will have a period of preliminary economic development in this area including operating a vast system of long-distance communications, a vast system of weather forecasting, and rocket transportation facilities."

–"Third we will advance our explorations to the rest of the solar system, including Pluto, Neptune, Uranus, Saturn and Jupiter."

Kerr paused pointedly; then added:

"We're no more prepared to forecast accurately the full significance of these developments and extent of their effect on society than Christopher Columbus would have been able to forecast accurately the development of western civilization following his arrival at San Salvador." #

Keen Mind for Space Problems . . .

ROBERT S. KERR, who was born in a log cabin, grew up to become an oil millionaire and finally moved to a Senate seat in 1949, takes over the chairmanship of the Senate Space Committee at a critical time in the East-West space race.

In fact, some observers contend this may well be the last critical time: The United States must surge ahead now or never.

Kerr typically makes no claim to space expertise. But the big, 64-year-old Oklahoma senator has one of the sharpest and quickest minds in Congress. And, with some rapid but solid briefing, he has been known to become an impressive and incisive expert on many abstruse matters on very short order.

Moreover, in whatever he undertakes, Kerr is a dogged and enthusiastic fighter as well as a master needler. It is in the latter art that he is most feared by his colleagues, who generally shy from verbal battle with him on the Senate floor.

Kerr faces the world with vast and much justifiable self-confidence. Characteristically, when he lost the Democratic presidential nomination in 1952, he said: "It would appear that the people do not realize what a superior product was being offered them."

For 12 years Kerr (as a member of the Public Works Committee) has championed conservation measures and (as a member of the Finance Committee) has interested himself in tax and social security problems. His campaign slogan has been: "Land, Wood and Water."

Now he's added two words. The Slogan is: "Land, Wood and Water—and Space."

Sticking with Atlas . . .

Mercury Men Balk at Switch to Titan

Booster change would only cause more slippage, NASA claims; 'fix' expected to correct source of recent Atlas explosions

OFFICIALS OF THE SLIPPING *Mercury* man-in-space program are strongly resisting a suggestion to the Kennedy Administration that they consider switching to a *Titan* booster because of the "marginal" reliability of *Atlases*.

They feel a changeover in boosters at this point would only mean more slippage.

Moreover, they believe the technical troubles which have caused failures in four *Atlas*-based lunar orbit vehicles and two *Mercury* shots have been located and can be corrected. NASA plans to launch 35 *Atlas*-based vehicles in the next three years.

The reaction from NASA was swift and to the point following the submission of a report on the nation's lagging space program to President-elect Kennedy (see pages 11 and 12) last week. The report by an Ad Hoc Committee said:

"The present *Mercury* program, based on the *Atlas*, is marginal and if the *Atlas* proves inadequate for the job it may be necessary to push alternatives vigorously. The first possibility appears to be the *Titan*, although it has not demonstrated the reliability which is required. We should study the desirability of carrying out a *Titan*-boosted *Mercury* program in the event *Atlas* should prove to be inadequate."

No time limits on the "adequacy" of *Atlas* were set forth in the report.

However, *Mercury* Chief Robert R. Gilruth indicated that he saw no need to even entertain the idea of switching to *Titan*. *Atlas* was chosen more than two years ago because it was ahead of *Titan* in development, Gilruth said, and "it is still ahead."

• **Mating problem**—Even if *Titan* were ready in a stage to use as a *Mercury* booster, the problem of mating the capsule would still exist and cause further delay. Just how much, Gilruth did not say.

It is in this area that the troubles have cropped up with *Atlas*. The problem seems to be at the upper end of the booster or in the capsule adapter ring. It is one apparently involving structural strength, bending moment and harmonic effects. If so, *Mercury* officials feel it will be comparatively easy to fix.

A partial fix will be attempted in *Mercury Atlas II* (MA-2) scheduled to be launched before the end of March. A complete fix, ordered as a result of the explosion of an *Atlas-Able* lunar orbit vehicle last month after 70 seconds of powered flight, will be tried with MA-3. As a result, MA-3 will slip into the second quarter of this year. It had been scheduled to go in the first quarter.

Gilruth also feels *Atlas* will be more reliable with a man aboard because all three of its main engines are ignited on the ground, where *Titan* involves a second-stage ignition in flight.

Cause of the failure of the escape system in the *Little Joe 5* test on Nov. 8 has been established as a malfunctioning limit switch, Gilruth reported. "The Navy recovered the guilty part."

The wiring and physical hookup were changed in time for the successful *Mercury Redstone I* shot last month. However, another *Little Joe* is being prepared for launching. This experiment, as well as the second *Mercury Redstone* (MA-2), which will carry a chimpanzee, must both be successful before a man is launched in a *Mercury* capsule.

• **List of 'musts'**—As for the *Atlas* tests, NASA's Space Task Group last week outlined a series of experiments that must succeed before the manned orbital shot. Assuming each experiment works the series might go as follows:

MA-2—repeat of MA-1 with several additional systems in the capsule.

MA-3—another ballistic shot with the entire life support system and a "mechanical man."

MA-4—a capsule containing a chimpanzee, either on a ballistic trajectory or in orbit. (Gilruth said there must be an experiment in which a capsule is inserted into an orbital trajectory and then the retrorockets are fired immediately to bring it back. Presumably this might be done with MA-4.)

MA-5—chimpanzee in orbit.

MA-6—man in orbit.

Gilruth said that if all experiments succeed, manned orbital flight is still possible in calendar 1961.

However, he emphasized that in a research development program firm schedules cannot be set and each step depends on the success of the previous steps. If any experiments fail, it must be repeated.

Asked about a House Space Committee report that estimated *Mercury* might cost as much as $500 million, compared with current official estimates of $393 million, Gilruth said it is entirely possible that it will prove desirable to make more manned flights than are currently programed. Under present plans, the Project *Apollo*, 3-man spacecraft is not due to begin manned flights until 1968.

Gilruth was asked whether work on *Apollo* could not move faster. He said he is not qualified to answer that question.

• **Busy astronaut**—Dr. Robert B. Voas, STG psychologist, declared that the astronaut will have seven major duties during the *Mercury* flight. They will be to monitor the sequence of flight events, manage and monitor on-board systems such as power, oxygen and communications, operate attitude control, navigation, communications, research and evaluation activities, and keep himself in condition to meet coming environmental stresses.

Research and evaluation activities, Voas said, include:

–Observation of capsule function, such as cues not automatically followed and investigation of non-programed situations.

–Scientific observations of earth and space.

–Measurement of his own performance, such as inability to perform assigned functions and the effects of weightlessness on his sensing and controlling abilities.

–Reporting his medical symptoms.

Dr. T. Keith Glennan, retiring NASA administrator, praised the degree of cooperation between NASA and military departments.

"People in both NASA and the Department of Defense are ambitious and imaginative," he declared. "In such a situation there will always be pulling and hauling. But there has been less controversy and more cooperation in the last year than anyone had any right to expect."

Major New Radiation Probe Readied

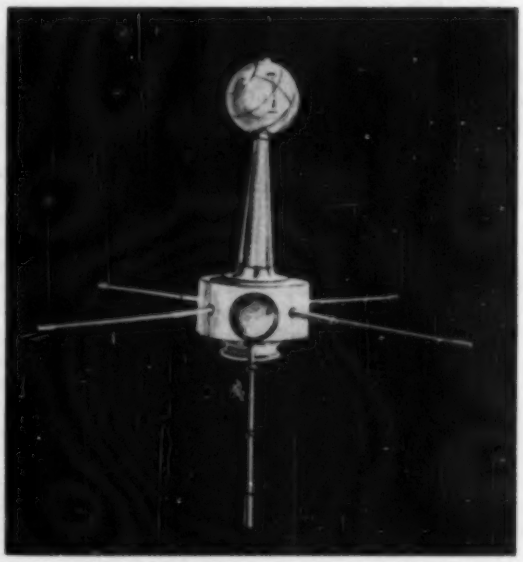
First details of NASA's P-14 payload designed to map magnetic fields in cislunar space with new rubidium-vapor magnetometer

by Charles D. LaFond and Jay Holmes

THE UNITED STATES soon will make its first major attempt to map the magnetic fields in cislunar space, an essential step toward preparing the way for manned flight to the moon.

March is the target month for launching a *P-14* probe with a new and extremely sensitive rubidium-vapor magnetometer as part of its payload. Developed by Varian Associates, Palo Alto, Calif., and NASA's Goddard Space Flight Center, the system employs optical pumping techniques to measure radiation intensity.

A *Delta* vehicle will boost the 75-lb. spacecraft in an attempt to reach an altitude of 140,000 miles—more than half the distance to the moon. The probe will then plunge back and burn up in the earth's atmosphere.



P-14 SPACE PROBE, due to be launched about March, is shown in this conception by a NASA artist.

Magnetic-field charting is essential to manned space flight. The hazardous charged particles in solar flares and the Van Allen radiation belts follow paths that curve according to magnetic fields, of which exact knowledge will make possible the prediction of both danger areas and relatively safe paths.

• **Highly sensitive**—U.S. scientists apparently are far ahead of Russia in developing sensitive magnetometers, although Russia's *Lunik II*, by virtue of being the first spacecraft to land on the moon, provided the first report—a negative one—on the lunar magnetic field.

Russian scientists said their instruments, sensitive down to a level of 60 to 100 gammas, detected nothing. However, American and other scientists had predicted beforehand that a lunar field of more than 50 gammas would be unlikely.

The new magnetometer will be sensitive down to 0.1 gamma and perhaps .01 gamma. Besides *P-14*, it will be aboard *Rangers I* and *II*, the prototype lunar rough-landing spacecraft to be tested on *Atlas-Agena B* flights scheduled for the last half of 1961.

The present state of knowledge about magnetic fields in space beyond the earth's field is largely based on measurements from *Pioneer V*, the U.S. space probe that transmitted from as far as 22½ million miles away last year. *Lunik I*, the first Soviet interplanetary probe launched Jan. 2, 1959, carried a magnetometer but it was sensitive only down to 100 or 200 gammas, according to Dr. James P. Heppner of the Goddard Center.

Pioneer V data indicated an interplanetary field of about 2 gammas, Heppner continued. This surprised researchers and will require a reworking of current ideas about the way clouds of protons and other particles travel outward from the sun, both in quiet periods and during solar flares.

• **New techniques used**—The optical pumping principle, basis of Varian's rubidium-vapor magnetometer, is related to those underlying the maser and the atomic clock.

The single outer electron of alkali metals such as rubidium, is easily excited to any one of a number of higher-energy levels by action of light. After a tiny fraction of a second, the electron falls back to the lower level.

But in even a very weak magnetic field, electrons line up with their spin axes pointing along the direction of the field. Two electrons can be aligned parallel, both spinning in the same direction, or antiparallel, spinning in opposite directions. When an electron flips over and spins in the opposite direction, it gains a tiny amount of energy, much smaller than the amount involved when it is raised to a new energy level.

This tiny amount of energy is equal to the energy in the spin a photon of light gives up when it hits an atomic particle and excites it. But when an excited electron falls back to a lower level, it sometimes drops to a level representing the increased spin energy that includes the photon spin.

At such a level, the electron cannot be excited to a higher state by the action of light. In the physicist's language, such a transition would be forbidden. Thus, electrons in the maximum energy state tend to remain there, just as water tends to remain in a pitcher when it is lifted into the pitcher by a pump.

Gradually, the action of light would pump energies higher and higher until all electrons were in the upper state if it were not for the fact that collisions with each other and with the container wall knock them down again, faster than the pumping.

• **Frequency Flip**—However, A. Kastler and J. Brossel of the Ecole Normale Superieure in Paris discovered in 1955 that some gases introduced into the alkali metal vapor as impurities have the effect of slowing the energy loss, allowing the pumping to proceed. The impurity atoms, acting as buffers, have different shapes and electron orbits, which results in their having less tendency to flip the electrons over.

H. G. Dehmelt of the University of

Washington discovered that hydrocarbons with long straight-chain molecules act as the best buffers, after which Arnold Bloom and W. E. Bell of Varian developed their magnetometer based on the use of optical pumping.

When electrons in a chamber of rubidium-vapor are pumped up completely, the chamber is perfectly transparent to circularly polarized light of a frequency characteristic of rubidium. In the normal, random state of the electrons, some of the light is absorbed.

The magnetometer is based on the fact that a specific low radio frequency, depending on the strength of the magnetic field, is required to flip the electrons over and undo the pumping. At that frequency, the amount of light absorbed suddenly increases. Thus, essentially, the new Varian instrument is an extremely high-resolution spectrograph. One used in a recent *Javelin* test was comprised of a 140-mc, r-f excited, rubidium lamp; optics—consisting of a rubidium filter, lens, and a circular polarizer; Rb gas cell; lens and mosaic light sensor; amplifier and transmitter; plus a 90° phase-shift feedback circuit connected to a coil around the gas cell. The system required 5 watts input.

In the *P-14* instrument configuration, two sets of gas cells, optics and amplifiers are used with feedback coils driven from alternate amplifiers to obtain the phase shift. This minimizes associated electronics and results in a lower power, more flexible, broader band system.

The output frequency from the magnetometer is proportional to the strength of the magnetic field environment. For *P-14*, an absolute vector magnetometer was developed by introducing a bias field commutated for six vectors.

• **60-hour output**—Additional equipment needed in the magnetometer package will include a 6-watt transmitter, four dipole antennas, an optical-aspect system, and battery pack.

The binary-output optical aspect consists of a slotted window which will feed data to a small digital computer for attitude reference. The computer provides a digital orientation reference for telemetering. This is necessary to interpret the field measurements more accurately since the payload will be spin stabilized.

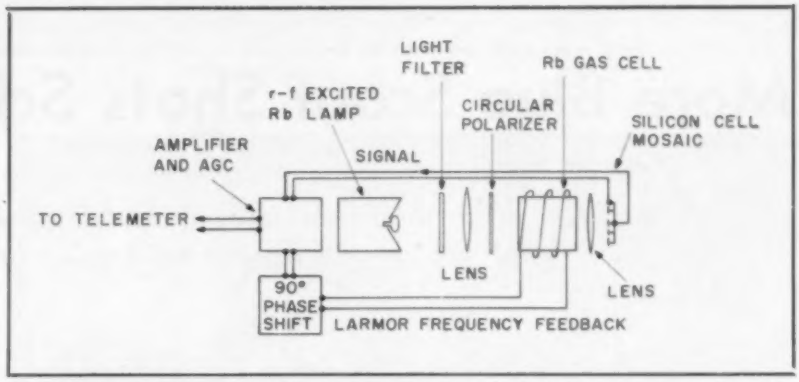
An 18-watt battery pack housed in the center of the payload will provide up to 60 hours continuous effective output. The 35-lb. cylindrical pack consists of 168 Yardney silver-zinc primary cells.

The magnetometer in the *P-14* spacecraft will require only about 3 to 3.5 watts. A magnetometer based on the proton-precession principle, such as that aboard *Vanguard III*, would require much more power to obtain equivalent sensitivity, Heppner remarked.

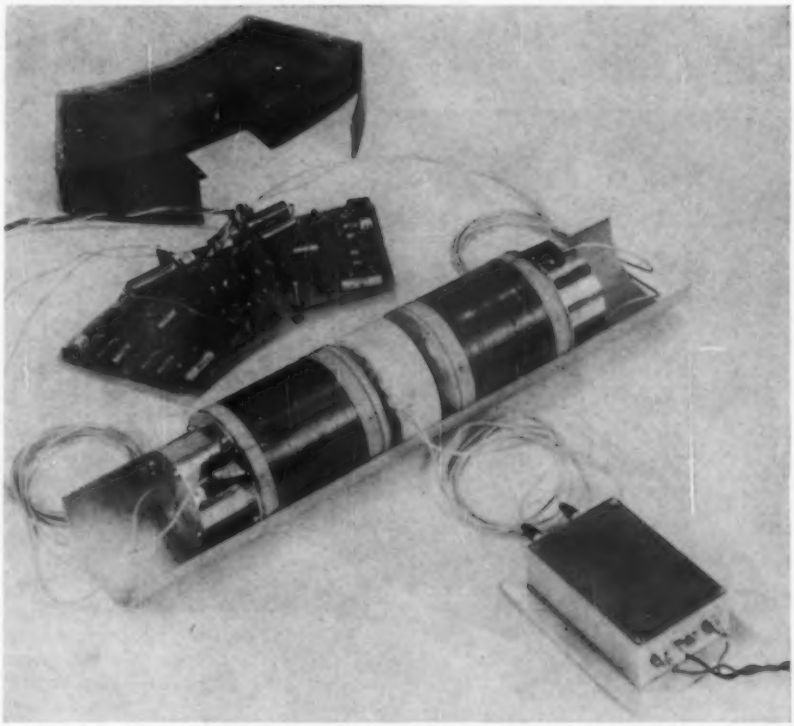
Proton precession magnetometers are inherently more accurate than those based on optical pumping, but they have a low sample rate. The weakest magnetic field measured by *Vanguard III* was 7000 gammas, at apogee over South America.

The magnetometer operated perfectly on a *Javelin (Argo D4)* sounding rocket launched Dec. 12 from Wallops Island, Va. The *Javelin* payload, weighing 35 lbs., rose to an altitude of 717 miles and telemetered data during the entire length of its flight. The *Javelin* payload was much lighter because it required only about 7 lbs. of batteries, good for up to 10 hours of operation, instead of 35 lbs. as in P-14, and the *Javelin* payload was not spin stabilized. *P-14* will carry lead weights on the outside to steady the spin.

The spacecraft, a large cylinder with a smaller sphere at the end of a rod extending from the cylinders' axis (see illustration) will carry two other scientific experiments, weighing a few lbs., in addition to the rubidium magnetometer. The main cylinder is constructed of magnesium, the sphere of a fiber glass plastic composition like that in the *Altair* rocket case. ⌗



RUBIDIUM-VAPOR self-oscillating magnetometer block diagram shows configuration used in the recent Javelin rocket test series launched from Wallops Island, Va.



DISASSEMBLED P-14 magnetometer showing (center) arrangement of dual rubidium gas cells and rubidium excitation lamp with the cannister.

More Blue Scout Shots Scheduled Soon

First test yields data from lower Van Allen belt, although capsule is lost; vehicle was biggest solid rocket fired from Cape

BLUE SCOUT I, the three-stage member of the Air Force family of all-solid sounding and orbital rockets, lifted a 392-lb. payload to 1000 miles altitude and plunged into the Atlantic 1200 miles down the Atlantic Missile range on its first flight test.

The research rocket radioed telemetry data from eight experiments during its stay in the lower reaches of the Van Allen radiation belt Jan. 7. On return, a 90-lb. instrument capsule separated and fell by parachute into the ocean northeast of Antigua.

A JC-54 search plane followed the radio beacon and spotted the capsule in the water late in the afternoon. However the recovery ship Coastal Crusader, 200 miles away, could not reach the area until the following morning; the capsule had disappeared by then.

It was understood that the distance traveled was somewhat short of the Air Force objective.

The stages of the 72-ft. *Blue Scout I* are identical with the first three stages of the *Scout*, developed by the National Aeronautics and Space Administration, except that it contains a destruct package and controls required to satisfy AMR regulations. No destruct package is required for *Scout* vehicles flown from the NASA station at Wallops Island, Va.

The *Blue Scout*, weighing 36,900 lbs., about 3900 lbs. heavier than *Polaris*, was the largest solid propellant rocket ever flown from Cape Canaveral. The record, however, will stand only until the 65,000-lb. *Minuteman* ICBM flies in the next month or so.

It was the second of the *Blue Scout* family to be tested. A smaller version, the *Blue Scout Jr.*, a 40-ft. vehicle whose first stage is the second stage of regular members of the *Scout* series, had one success in two flights last fall.

• **More shots soon**—The Air Force plans to test the two other members of the *Blue Scout* family in the next few months. One is the Air Force *Scout*, identical to the four-stage NASA *Scout* except for beefed-up structure between final stage and payload, and a large payload compartment. The other is *Blue Scout II*, which has guidance in the fourth stage. The other regular *Scouts* have a semi-inertial guidance package in the third stage. *Blue Scout Jr.* is unguided.

Aeronutronic Division, Ford Motor Co., is the Air Force's prime contractor on the *Blue Scouts*. Chance Vought, NASA's prime *Scout* contractor, is a major Air Force associate contractor, in charge of vehicle assembly. *Blue Scout I* propulsion contractors are Aerojet-General, Thiokol and Hercules Powder Co. Minneapolis-Honeywell developed the guidance.

Both the Air Force and NASA plan to use *Scouts* for testing vertical and angular launch techniques, boost-glide and boost-dive trajectories and recovery techniques. A number of *Blue Scout* shots are programmed for support of the *Dyna-Soar* development.

• **PMR possibility** — Most *Blue Scout* launches are scheduled for Cape Canaveral. However, several tests involving polar orbits may be fired down the Pacific Missile Range. The *Blue Scout* R&D phase, comprising 12 launches, is scheduled tentatively for completion when the current fiscal year ends in June. However, since NASA also is testing *Scouts*, Air Force technicians hope the NASA results may eliminate the need for two or more tests.

The 1962 AF budget request will include *Blue Scout* production funds.

The eight experiments aboard were aimed at measuring radio frequency background radiation in the 50 cycles-100 kilocycles band; concentration, size and flux of micrometeorites; flux of backscattered albedo neutrons; concentration and energy distribution of charged particles in the upper atmosphere by time and position; electronic signals above and below the ionosphere cutoff; ion density in the upper atmosphere; aerodynamic turbulence along the launch vehicle surfaces and acoustic and vibration environment of the payload, and radiation dosage for evaluation hazards to manned flight.

The 90-lb. capsule carried a miniature tape recorder to register velocity and payload temperatures. ‡

BLUE SCOUT payload sheds heat shields in artist's conception. Air Force reported satisfactory telemetry from all eight experiments, despite failure to recover capsule.

Bell Set Record in 1960 For One-Year Profits

THE BELL SYSTEM showed more profit in the twelve months ended Nov. 30, 1960, than any company has ever cleared in a year.

American Telephone and Telegraph Company and its telephone subsidiaries had an income of $1,244 million. Previous high for any company was set by General Motors Corp., $1,189 million in 1955. The Bell System posted $1,136 million in profits last year.

Bell is "hopeful" that it will be able to launch a communications satellite within a year, according to president Frederick R. Kappel. The company is preparing to furnish intercontinental telephone and TV channels through satellite communications systems, he disclosed.

The Bell System has applied to the Federal Communications Commission for microwave radio frequencies for experimental use.

Magnavox Co.—The highest levels of sales and earnings in the company's fifty-year history were attained. Earnings for 1960 rose by about 40% to 6.5 million from the $4.7 million the previous year. Sales rose 15.5% to $124.5 million from $107.8 million the previous year. The company reported that its military and industrial electronics products division increased its sales 35% for the twelve-month period, and doubled its fourth quarter of a year ago.

Titan II 2nd-stage Engine

FIRST PHOTO of Aerojet-General's mockup of the second-stage engine for the advanced Titan II ICBM, taken during a review at the company's Sacramento plant.

corporate changes

NATIONAL RESEARCH CORP. has purchased a controlling interest in Vacuum Apparatus Company, Palo Alto, Calif.

GENERAL ELECTRIC's Silicone Products Department will construct a $1-million process plant devoted to production of new types of intermediate silicone chemicals. The Department, at Waterford, N.Y., also has under construction a $1-million silicone fluids finishing operation and a $3-million plant for the manufacture of silicone chemicals intermediates.

AMERICAN MACHINE AND FOUNDRY has acquired Paragon Electric Company of Two Rivers, Wis., subject to a Paragon's shareholder meeting.

HUGHES AIRCRAFT COMPANY and SABCA, a Belgian aircraft corporation have formed a new company in Belgium. Named COBELDA, the company will provide technical assistance and maintenance for electronic equipment deployed in Europe and support service for the Hughes ground and airborne radars on the continent.

U.S. INDUSTRIES, INC.'s Western Design and Electronics Division has completed negotiations to build a 60,000-square-foot office and plant facility in the Goleta Valley outside Santa Barbara.

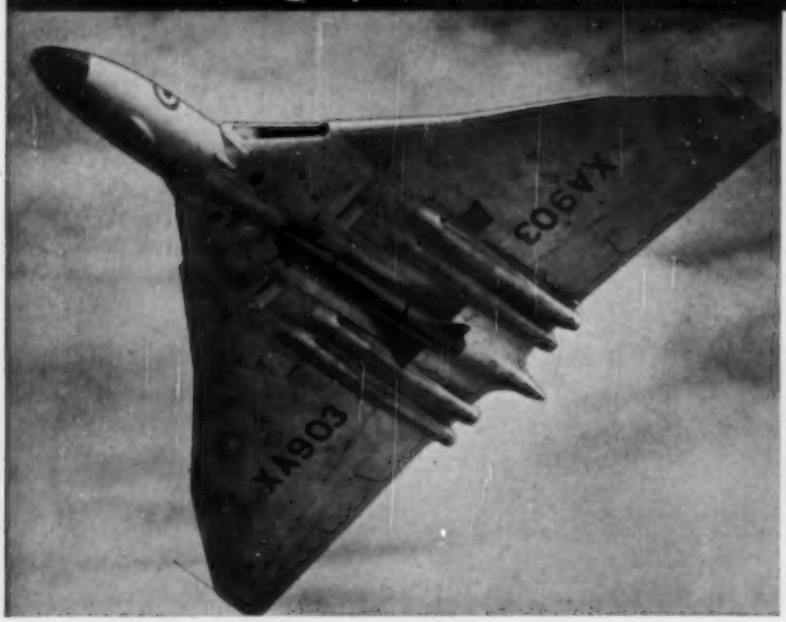
AEROSPACE RESEARCH INC. has been formed by L. Dennis Shapiro, former chief of space research section, Pickard and Burns, Inc. The firm will be located in Cambridge, Mass., and specialize in research and development in radio propagation, communications and ionospheric physics.

GENERAL MOTORS will move its Aeroproducts Operation in Vandalia, Ohio, to the Allison Division at Indianapolis, pending Air Force approval. Plans are being made to utilize the Vandalia facilities for other production within less than a year.

BECKMAN INSTRUMENTS INC. has begun construction of a $1.25 million building to house its Systems Division at the company's Fullerton, Calif., headquarters plant. The 100,000-sq.-ft. building will be occupied in May, 1961.

FORD MOTOR CO.'s Aeronutronic Division has changed the name of its Research Operations to Research Laboratories . . . American Radiator and Standard Sanitory Corp.'s Detroit Controls Division will be known as the American-Standard Controls Division.

Britain's new deterrent system relies on two high-performance vehicles...



...AND BRISTOL SIDDELEY SUPPLY THE POWER

Bristol Siddeley Engines Limited produce the powerplants for two vehicles which make up the most advanced weapon system within Britain's strategic deterrent force—the Avro Blue Steel "stand-off" bomb and its carrier aircraft, the Avro Vulcan V-bomber.

The Bristol Siddeley Stentor liquid propellent rocket engine powers Blue Steel. The Stentor is a high-thrust engine which burns kerosene and hydrogen peroxide. Its exceptional performance enables Blue Steel to be released from the carrier aircraft *well outside the enemy's defence zone*. Blue Steel, which can be more accurately described as an air-to-ground missile, then continues under its own power and seeks out the target with great accuracy while the carrier aircraft returns to base.

The Bristol Siddeley Olympus turbojet, Britain's most powerful military aero-engine, powers the Avro Vulcan, and gives this delta-winged carrier of Blue Steel sonic capability, great range, high altitude.

BRISTOL SIDDELEY ENGINES LIMITED

Bristol Aero-Industries Limited, 200 International Aviation Building, Montreal 3, Canada. Telephone: University 6-5471

Bristol Siddeley Maybach diesel engines power the British Railways "Bristolian".

The Bristol Siddeley Marine Proteus powers the "Brave" class 96 ft. Royal Navy patrol boats.

The Bristol Siddeley Industrial Proteus gas turbine engine powers a 3-megawatt turbo-generator.

Circle No. 7 on Subscriber Service Card.

Technical Countdown

ELECTRONICS

PARADE: Still a Silent March

The Army's very-secret PARADE (Passive-Active Range Determination) still is wrapped in impregnable security. Funded by Ordnance at Redstone Arsenal, ($3.1 million, so far) Sylvania is believed well under way with a prototype contract awarded last year. The electronic counter-countermeasures system has been under development by the company's Data Systems Div. since a study contract in 1955. A follow-on feasibility program was begun in 1957.

Global Radio Station Nears Completion

The Navy's two-megawatt global communication station at Cutler, Maine, has successfully passed preoperational tests. One year ahead of schedule, the nearly complete $50-million station uses the world's most powerful transmitter for communication with operational *Polaris* submarines. Continental Electronics Mfg. Co., a subsidiary of Ling-Temco, is prime contractor for the complete installation.

New Look at Universe Coming Soon

A series of ultraviolet telescope packages will soon be carried in *Aerobee-Hi* rockets to an altitude of 150 miles over Wallop's Island for Project *Celescope*. Carrying a Uvicon—an ultraviolet sensitive tube developed by Westinghouse—the system will employ TV techniques for celestial observations above the atmosphere. This will be an early test of one of several instrument packages destined for use in NASA's orbiting astronomical observatory satellite (*OAO*) due for launch in 1963.

SUPPORT EQUIPMENT

'Do-It-Yourself' ComputerMat Established

Computer time on a self-serve basis has begun with the opening of the first of several "ComputerMats" planned for the Los Angeles area by ComputerMat, Inc. The new "do-it-yourself" computer center uses an IBM 1620 transistorized, decimally operated, core memory computer. The decimal 1620 allows an inexperienced operator to solve his own engineering and scientific problems with a minimum of instruction.

Ideas Needed on Weather Data Reduction

Dr. Morris Tepper, NASA chief of weather satellites, is looking for good ideas for analysis of weather observations aboard the advanced *Nimbus*, to reduce the flood of data that will be transmitted to the ground. He says he will be receptive to any specific plan of data analysis from anyone who understands meteorology. Data storage aboard the satellite is one possibility.

Pershing Explosion Unrecorded

Lack of good news photos of the spectacular *Pershing* blowup of Jan. 5 was attributed to inadvertent lockup of a tracking camera. By the time the camera was unlocked and operating again, all that remained of the missile was bits and pieces falling back to earth.

MATERIALS

Price of Fluorocarbon Resins Reduced

Responding to an expanding market and manufacturing economies, DuPont has reduced the prices of its "Teflon" resins. The basic resin now stands at $3.25 per lb. in truckload lots. "Teflon" 100 FEP-fluorocarbon resin, useful in wire and cable applications, was cut to $9.60 per lb.

Computer to Tackle Space Thermal Problems

Douglas Aircraft has ordered a thermal analog computer for use in the *Saturn*, *Skybolt* and *Nike-Zeus* programs. Thermal problems associated with re-entry and space payloads may be simulated and varied in seconds by rotating a switch. Computer Engineering Associates is building the instrument, which will include 29 special thermal radiation units.

Copper Joining Process Reduces Cost

A special coating on the surfaces of copper metals to be joined diffuses into the parts and, under certain conditions produces a homogeneous bond without an interface. Chase Brass & Copper Co., developed the method. Complete diffusion, braze, and combined diffusion and braze bonds are possible. The joints retain virtually all of the electrical and thermal characteristics of copper.

PROPULSION

NASA Reduces Space Payloads

NASA's chart of launch vehicle capabilities has reduced several figures in the interest of realism. New payloads: *Scout*, 150 lbs. in orbit instead of 150-200 lbs.; *Thor-Agena B*, 1250 lbs. in orbit instead of 1600 lbs.; *Atlas-Agena B*, 5000 lbs. in orbit instead of 5300 lbs., and 750 lbs. to escape velocity instead of 800 lbs.; *Saturn C-1*, 19,000 lbs. in orbit instead of 20,000 lbs., and 5000 lbs. for escape instead of 9000 lbs. *Centaur* retains the same orbital capacity—8500 lbs.—and its escape capability rises from 1450 lbs. to 1500 lbs.

Aerobee to Research Hydrogen Weightlessness

NASA is planning to launch an *Aerobee* sounding rocket from Wallops Island in the next few weeks to observe what happens in a 9-in. sphere partly filled with liquid hydrogen during five minutes of weightlessness. A camera will record how the cold liquid is distributed in the sphere to provide data that will help in designing the *Centaur* for restart in space. The 250-lb. payload will reach 118 miles altitude and is designed for both air snatch and recovery from the sea if snatch fails.

Work Begun on No. 2 Saturn

Huntsville has begun construction of the second flight *Saturn*, while work is finishing on the first, due to be static-tested after the current series of tests is completed on the prototype booster. Meanwhile, an extension to the Fab Lab is being built to make possible simultaneous construction of three boosters.

Will USSR Lead in Applied Math?

Russians are doing better job of coordinating the theoretical and the practical, RIAS reports, with strong stress on plant automation

The opinion is sometimes advanced that the new technological revolution in the Soviet Union will be the practical use of atomic energy as the most powerful source of energy. This is not the case. In fact, it is automation moving productive processes under their own power that today plays the same decisive role that was played by power machines in the industrial revolution of the 18th century.

(From a report of a meeting of the academic Council of the Institute of Automation and Telemechanics of the Academy of Sciences, USSR, May, 1959.)

by William Beller

THE SOVIET UNION may soon pull ahead of the United States in applied mathematics.

In theoretical mathematics, the USSR is equal to the U.S.

The USSR is putting strong emphasis on the mathematics of automatic control problems. It appears that through automation—through accurately guided spacecraft and automatic factories—the country hopes to prove its technical superiority.

In addition, the USSR seeks to show that only a communist society can carry out the automation of industry without a breakdown in its economy.

These are some of the conclusions reached by a star panel of mathematicians organized by RIAS (Research Institute for Advanced Studies) to report on recent Soviet contributions to mathematics.

The panel points out in its year's study that the USSR encourages the application of mathematics by its mathematicians. This is in sharp contrast to the U.S. where there is a growing gap between pure mathematicians and those interested in applications.

The panel adds that there are a large number of Soviet mathematical-engineers who keep up with the latest mathematical developments and use them in practical work. There is no counterpart to this group in the U.S.

Here are other observations made by the panel:

–Soviet mathematicians strive to communicate the latest theoretical advances to engineers and scientists. In the U.S., specialists write for each other.

–Applied mathematics is respectable in the USSR. For this reason, the field is attracting many young people. On the other hand, among the pure mathematicians in the U.S. there is an increasing tendency toward greater and greater abstraction.

This tendency is discouraging young mathematicians from even looking at applications. Partly by U.S. default then, the Soviet Union will be gaining

Martin's Answer: RIAS See[now]

BENDER

THE MARTIN COMPANY set up the Research Institute for Advanced Studies (RIAS) in 1955 to see if basic research could be made into a respected investment for private enterprise and the government.

RIAS' books have yet to show a profit. Still, the organization is now meeting about half its expenses. The intangible rewards to Martin are felt to be making up the difference.

One such reward stressed by Martin board chairman and chief executive officer George M. Bunker is that "RIAS opens to Martin engineers a window of science that didn't exist before."

RIAS is made up of about 90 top research scientists working in manor house surroundings on an estate north of Baltimore. They are engaged strictly in searching for knowledge—whether or not it has any practical use.

There are staff members studying biochemistry and the biophysics of photosynthesis. Others are looking into the concepts of quantum chemistry and the phenomena associated with superconductivity. There is a group of 15 mathematicians whose only responsibility is to learn more about mathematics.

• **Increases general welfare**—The organization's first and present director, Welcome Bender, is a purposeful man who spearheaded the concept of RIAS. He is energetically trying to sell to other companies and the government the idea that "basic research is a national resource and should be exploited."

"We must do something to make basic research attractive," Bender insists. He says that even though we lead the world in technology, we are not operating at our maximum because we don't have the basic research inputs. "Science—which buttresses technology—has not had nearly the expansion that technology has had."

Bender calls the financing of basic research a government responsibility. He says that under the Constitution the Congress is charged with providing for the general welfare. "What is more relevant to the general welfare than basic research?" he asks.

The RIAS director bristles at what he calls a current concept that basic research should be subsidized, "like a poor relation." He maintains that it

n applied mathematics.

–An increasing number of Soviet mathematicians are working on control theory and numerical analysis. In quality of work, they match the U.S. In quantity of output and in number of people in the field, the USSR leads the world.

–Mathematics and mathematicians are protected by their own prestige in the regulated USSR society.

–Mathematics books in the USSR are amazingly cheap and good. In price, the U.S. books can not even compete. This gives the Soviets an exquisite scientific weapon and in addition a means to influence scientists in other countries.

• **Control and stability**—Mathematical research in the theory of control is carried on at two levels in the Soviet. In the first, there is a strong group of pure mathematicians developing a general theory of optimal control. They are also working on problems in differential equations and stability that relate to control theory.

On the second level, there is an equally strong group comprising mathematical-engineers. It is more directly concerned with applications. Mathematicians in the U.S. call members of this group "engineers" while American engineers who know them call them "mathematicians."

The mathematical-engineers are described as making important mathematical contributions and following closely mathematical research, working on engineering problems, and interpreting and transmitting mathematical results to engineers.

This group is reported to be better informed about the work of American mathematicians on control theory than are American engineers.

The panel observes that the USSR is "mounting a total scientific effort in automatic control." This effort is contrasted with that in the U.S. where "there is no balanced program . . . (and) where developments in automatic control are primarily in the hands of engineers."

Because of the Soviet's greater effort in the mathematics of control and stability, the panel sees the USSR's progress in the field being faster and theories being applied earlier than in the U.S.

• **Numerical analysis**—The USSR is giving much attention to computers and the related fields of data processing and automatic control equipment. As a result, a large part of the world's research in numerical analysis, of excellent quality, is being done in the USSR.

Books on numerical research are being produced in mammoth editions. They are widely distributed and frequently written to appeal to large, relatively unspecialized audiences.

An example cited is Sobolev's book on applications of functional analysis in mathematical physics; and to the exposition of Panov on numerical methods for solving hyperbolic differential equations, oriented toward engineering applications.

The most outstanding Soviet mathematicians are said to be taking a keener and more active interest in numerical analysis and computational methematics than their Western colleagues. This can not help but give strong impetus to the growth of Soviet numerical analysis and also to computer design.

• **Statistics**—The quality of the work in probability theory, information theory and mathematical statistics in the USSR is on the same level as that in the U.S. Much of the work has been done in two areas of practical interest —queuing theory and statistical quality control.

Because of the importance of applied statistics, there have been many Soviet books derived from the subject. These range from a text on least squares by Linnik, written for mathematical statisticians, to books by Cebotarev and Lukomomskii written for workers in geodesy, and for engineers and economists, respectively.

The full report of the RIAS panel will be published this spring by The Macmillan Company.

The panel members were: J. B. Diaz, Univ. of Maryland; Robert Fortet, Inst. of Henri Poincare; J. H. Giese, Ballistic Research Lab., Aberdeen Proving Grounds; R. A. Good, Univ. of Maryland; J. P. LaSalle, RIAS; Solomon Lefschetz, RIAS; Tadeusz Leser, Ballistic Research Lab.

Eugene Lukacs, Catholic Univ.; Ceslovas Masaitis, Ballistic Research Lab.; Edith Mourier, Univ. of Poitiers; J. Neveu, CNRS, Paris; Lajos Pukanszky, RIAS; H. A. Steeves, RIAS; and A. P. Stokes, RIAS.

ee**lnowledge for Its Own Sake**

should no more be "subsidized" than should road-building or the Navy or missile-building. He declares that basic research can pay its own way—by increasing the country's culture and its well-being.

Quoting a National Science Foundation study by Raymond Ewell, Bender points out that "the increments to gross national product in new business spawned out of basic research in the last quarter of a century amounted to $25-$50 for each dollar spent."

• **Big job, little money**—The traditional methods of financing science are inadequate, Bender maintains, for the following reasons:

–There is no longer enough philanthropic money in the universities to pay for the research demanded by our expanding gross national product.

–The cost per increment of new knowledge has expanded more than the normal inflation because new knowledge is harder to come by.

–Government laboratories, because of their lack of competitive atmosphere and their relative inflexibility, have a problem getting and keeping top talent except under wartime conditions.

–For industry, the pay-off appears to be far away—and in general is not proprietary.

• **Who pays the bill?**—One of the biggest impediments to basic research is the fact that a man with an idea is often actually penalized. "Several (government) agencies hold to the rule that if the subject of research is suggested by the agency, it is willing to support full costs; but if it is suggested by the research scientist, it is only willing to support a part of the cost."

The government also seems to be continuing with the old idea that somewhere there is a good philanthropist who will pick up at least part of the tab for basic research and then give its results freely to the world.

As a matter of fact, "To insure the continuance of this vestigial attitude, Congress has put statutory and abritrary limits on grants from NSF and NIH, which hold government participation to direct costs and 15% of indirect costs," says Bender.

However, Bender points out that the picture is not all black. With the establishment of ONR after the war—then ARDC, OSR, OOR and the many technical services of the military—an increasing emphasis on basic research has been realized. The AEC, NIH, NSF and now NASA are additional agencies deeply involved in using tax dollars in the interests of science. ⌗

New Drive Should Enhance Missilery

Harmonic Drive—based on brand new concept of transmitting motion through deflecting members—offers solutions to radar and other problems

by Richard W. Daniels
Director, New Product Development
General Industry Group
United Shoe Machinery Corporation

A NEW PRINCIPLE of mechanics that uses controlled deflection of operating members to transmit, convert or control mechanical motion is being applied increasingly in the missile field.

Besides being useful for driving, tracking and airborne radar antennas, it appears to be ideal for transmitting power through hermetically sealed housings or bulkheads.

The requirements for small-size, lightweight and high reduction ratios for radar drives, whether for ground based installations or airborne systems, has been of some concern to missile designers for several years. Moreover, the problem of minimum—in some cases practically zero—backlash, plus the need for high torque capacity and low friction losses, has further complicated the design of transmissions using conventional spur or planetary gearing.

The development of a compact, high-efficiency drive that operates on the principle of controlled deflection of the transmission elements now gives promise of overcoming many of these previous difficulties. In fact, if the success of the military installations that have been made to date is any indicator, its advantages may well prove to be a significant contribution to the missile field.

Still another use receiving increasing attention of late is for component and control drives in missile engines and navigational gear. Hardware for this purpose has already been delivered, and many other designs are in the prototype or engineering stages. In this case, it is the ability of the drive to transmit rotary-to-rotary, rotary-to-linear, or linear-to-rotary motion through hermetically sealed enclosures that interests the missile industry.

The exact nature of other applications that may develop in the future is difficult to predict at this time. But the fact that Harmonic Drive represents a completely new mechanical concept is certain to set designers thinking. Heretofore, mechanical transmissions have been designed around the principles of rigid body mechanics. They utilized elements whose deflection, if any, was purposely made minimal.

In contrast, Harmonic Drive devices, based on the elasto-kinesis principle, contain elements that are deliberately deflected when in operation. Such drives can be designed to provide speed reductions of up to millions to one; to provide a high torque rating, high torsional rigidity, and high operating efficiency; and to offer other advantages, such as zero or reduced backlash and less windup under load. Morever, rotary-linear versions can provide extremely fine and accurate positional control.

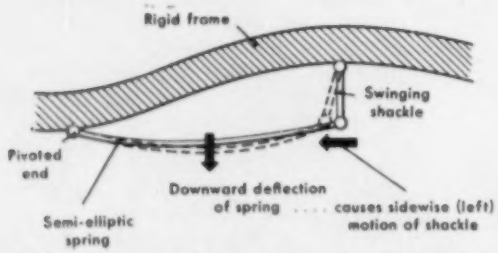


Fig. 1—*Leverage and motion conversion are obtained by controlled deflection of operating elements.*

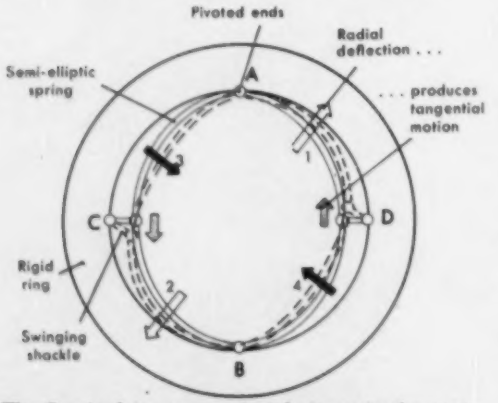


Fig. 2—*Applying same principle in a circular member converts radial deflection to tangential motion.*

Leverage by Controlled Deflection

While there are many variations of Harmonic Drive, the basic principles involved can best be explained through development of the rotary to rotary motion transmission. All forms of Harmonic Drive utilize a traveling deflection wave and the motion conversion which results from an advancing wave shape.

In Fig. 1, a simple example of "leverage by controlled deflection" is illustrated. Here, a semi-elliptic spring is shown with one end mounted on a fixed pivot, and the other attached to a swinging shackle. A downward deflection of the spring increases the spring curvature, decreases the chord length, and causes the swinging shackle to move to the left. A form of right-angle lever thus results from the spring deflection action of Fig. 1, and is capable of high force leverage or mechanical advantage.

In Fig. 2, semi-elliptic springs are mounted within a rigid circular ring, and are pivoted at points A and B and attached to swinging shackles at points C and D. An outward radial deflection in regions 1 and 2 increases spring curvature in these regions, but decreases curvature in regions 3 and 4. As a result of this radial deflection, the swinging shackles at C and D move tangentially as shown.

Harmonic Drive as a Rotational Machine

The final step to convert the simple spring deflection system into a continuous rotational machine is shown in Fig. 3. Here, two toothed parts are employed which mesh together in a manner similar to splines. The outer part is a rigid circular ring with internal spline

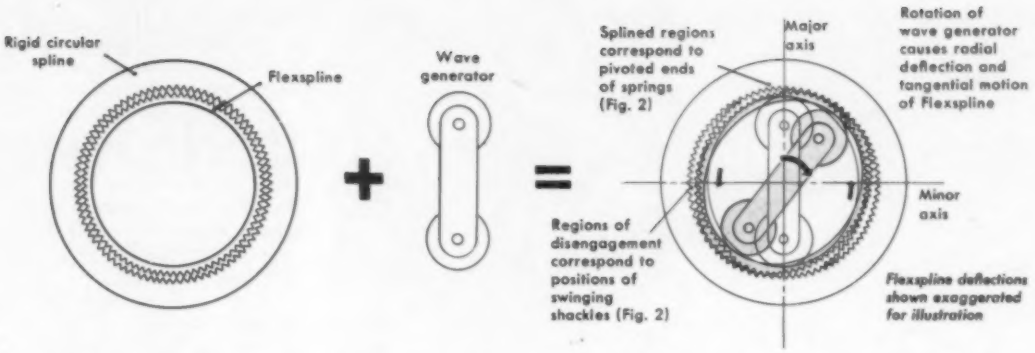

Rigid circular spline
Flexspline
Wave generator
Splined regions correspond to pivoted ends of springs (Fig. 2)
Major axis
Rotation of wave generator causes radial deflection and tangential motion of Flexspline
Minor axis
Regions of disengagement correspond to positions of swinging shackles (Fig. 2)
Flexspline deflections shown exaggerated for illustration

Fig. 3—*Schematic diagram of a basic three-element Harmonic Drive. The wave generator—in this case a two-element roller—can also take the shape of an elliptoidal cam in the form of an elliptical bearing or of a ball planetary generator.*

teeth; the inner part is a relatively thin flexible ring carrying external spline teeth. It is the unique functioning of this inner part, called the "Flexspline," that carries Harmonic Drive into the realm of non-rigid mechanics.

The third element in rotary Harmonic Drive is the "wave generator," which rotates within the Flexspline, deflecting it slightly from its natural circular form into an ellipse-like shape termed an elliptoid. The wave generator, in essence, provides the radial deflection force and radial displacement illustrated in the schematic structure of Fig. 2.

With the two-lobe wave generator shown in Fig. 3, the Flexspline is deflected into an elliptoid and meshes with the circular spline at two diametrically-opposite regions on the major axis of the elliptoid. Teeth of the two splines clear at the minor axis.

Teeth on the Flexspline and circular spline are cut to the same circular pitch, with the smaller Flexspline carrying slightly fewer teeth than the circular spline. To allow engagement at two diametrically opposite regions, the tooth arrangement must be symmetrical. For a two-lobe system having two regions of tooth engagement, the difference in number of teeth on the two splines must be 2, 4, 6—i.e., an integral multiple of the number of lobes. The pitch circle of the Flexspline is made smaller than that of the circular spline by an amount related directly to the difference in the number of teeth.

The splined regions of engagement in Fig. 3 correspond to the pivoted ends of the semi-elliptic springs in Fig. 2; whereas the minor axis regions of spline disengagement correspond to the positions of the swinging shackles of Fig. 2.

As the wave generator is rotated clockwise, the Flexspline is deflected progressively outward, causing continuous and greatly reduced tangential motion of the Flexspline. Motion of the Flexspline is in a counter-clockwise direction (CCW), for clockwise (CW) motion of the wave generator. For a

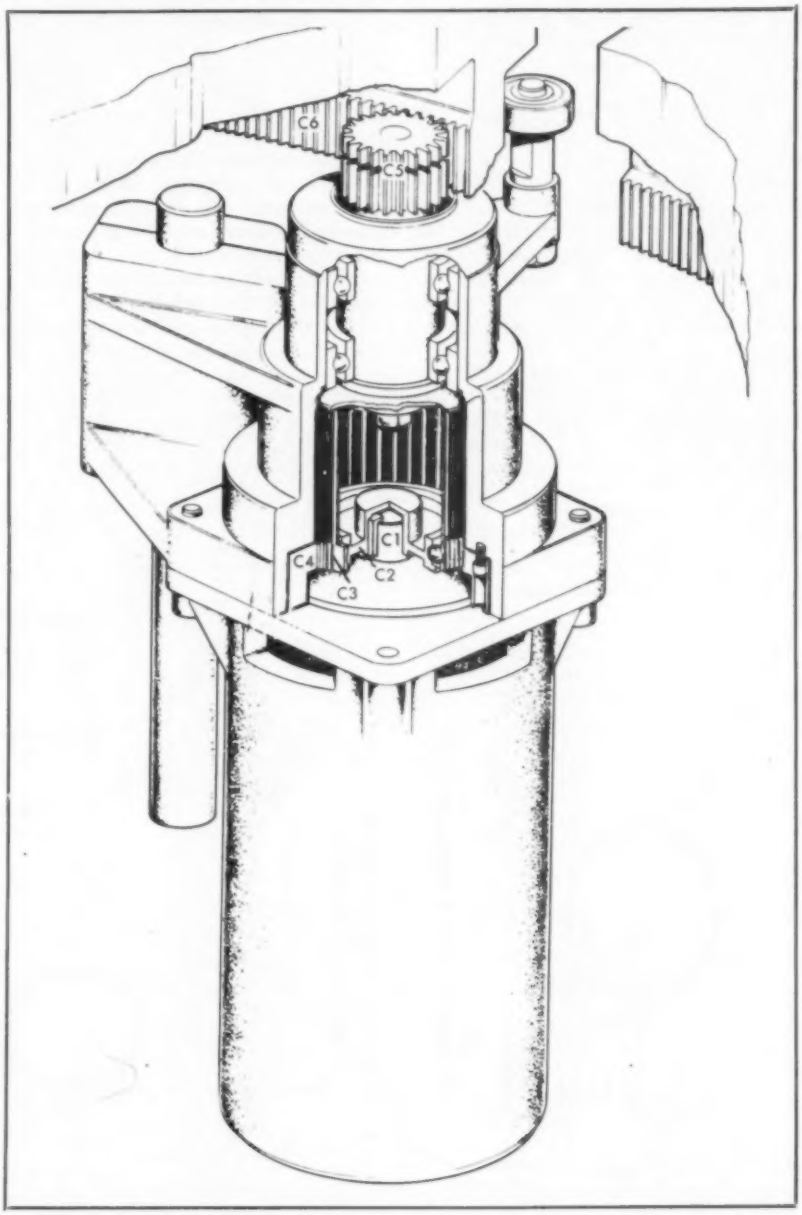


Fig. 4—*Speed reducer for the input to a radar tracking antenna has a reduction ratio of 172:1 and an output torque rating of 380 in.-lbs.*

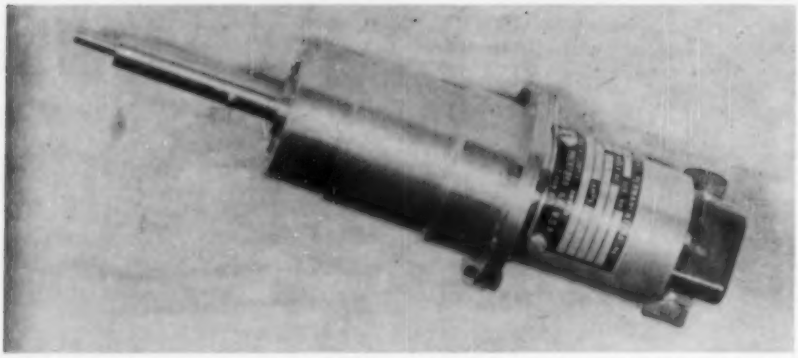


Fig. 5—*Small power servo designed for airborne radar system has 104:1 reduction ratio and a maximum output torque rating of 85 in.-lbs., is light and compact.*

full rotation of the wave generator, the Flexspline will counter-rotate by the difference in the number of teeth on the two splines.

The distinctive characteristics of Harmonic Drive can be seen from the simple rotary model of Fig. 3. The Flexspline and circular spline are firmly splined together at the major axis, but move angularly to one another at all other points, with maximum relative motion occurring at the minor axis.

If the wave generator is rotated clockwise (CW) at a constant angular velocity, the Flexspline will counter-rotate at a constant, but greatly reduced, average angular velocity in the counter-clockwise (CCW) direction. This is the basis for high reduction rotary Harmonic Drive systems.

Missile Radar Drives

Three drives in particular, among the many that have been developed, give a good indication of the potentials for the transmission in missile radar. One is an azimuth drive for a ground tracking antenna; another is an extremely small, lightweight model that is being designed for one of our more advanced airborne missiles; and a third is a high ratio, 40,000 to 1 unit, that was developed for an azimuth drive for a satellite tracking radar system.

In the azimuth drive shown in Fig. 4, controlled deflection in the form of an advancing wave shape is generated by an elliptical ball bearing whose inner race is coupled directly to the output shaft of an electro-servo motor (C 1). The rotation of the bearing, or elliptoidal cam (C 2), causes the teeth on the circular spline of the flexible ring (C 3) to engage at the ends of its major axis with similar teeth on the inner face of the internal spline on the housing (C 4). These teeth then disengage at the ends of the minor axis. Since the Flexspline has two teeth less than the fixed internal spline, it progresses around the internal spline in the opposite direction to input rotation and at a reduced speed.

Two transmissions are used per antenna. Mounted on opposite sides of an external bull gear in order to balance the input torque and insure better control of rotation, they have an output torque rating of 380 lb-inches, and provide a reduction ratio of 172 to 1.

Primary advantages of this transmission are its small size, light weight and high reduction ratio. Measuring only 11½ inches long and approximately 6¼ inches high and 4¾ inches wide, it is approximately one-third the size and one-half the weight of a conventional spur gear drive. Each unit, in fact, weighs only 20 lbs., of which approximately 10 lbs. is accounted for by the mounting arm requirements that were established for the previous drive.

Equally important, backlash is less than 30 seconds. A unique anti-backlash device is incorporated in the design to eliminate backlash between the output pinion and mating bull gear. Another advantage in this application is the low

(Continued on page 33)

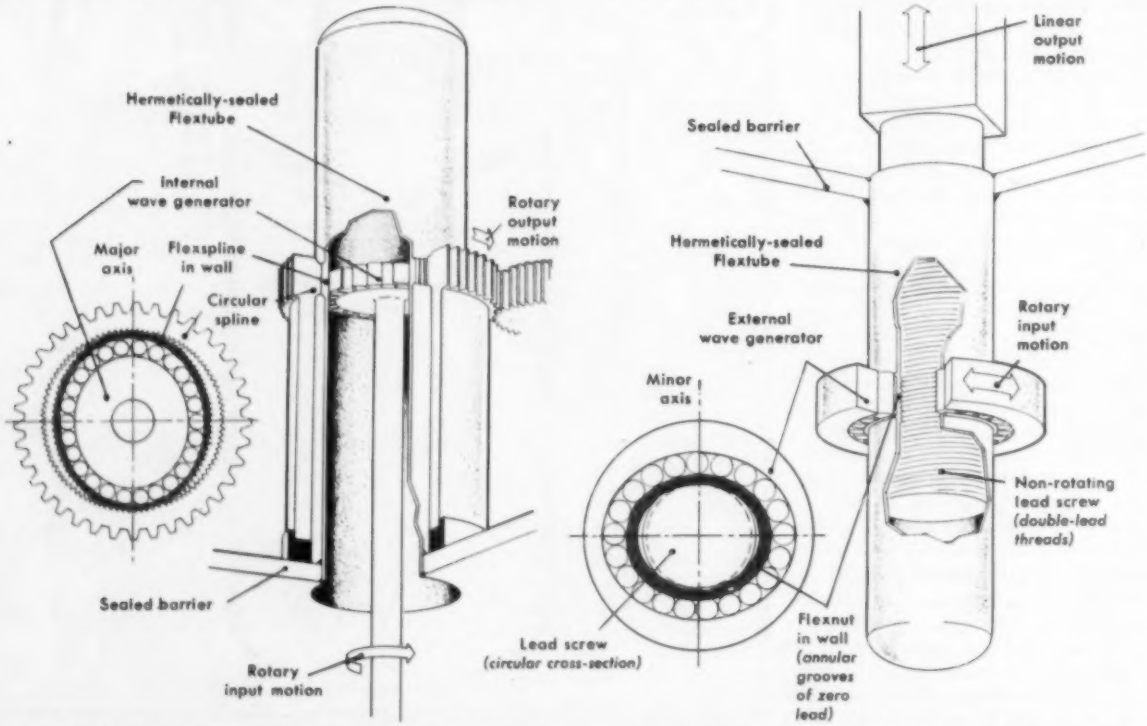


Fig. 6—*How Harmonic Drive can be employed to transmit rotary motion through a hermetically sealed barrier (at left), or to convert rotary input motion to a linear output through a barrier (at right).*

support equipment

Marshall's $70-Million Building Boom

PROJECT SATURN facilities will get the bulk of $70 million being spent for construction by NASA's Marshall Space Flight Center.

Funds will be about evenly divided between Cape Canaveral and the Huntsville Center.

Biggest single item in the budget for Huntsville is $10.8 million for a new *Saturn* booster static test facility. This facility is now being designed by Aetron Division of Aerojet-General with construction contracts due for award next fall.

Other *Saturn* work at Huntsville includes a $140,000 booster loading dock due for completion this month.

Contracts for building the $4.4 million headquarters and laboratory are expected to be awarded next June.

Facility modification and expansion at Huntsville includes:

–Pressure test cell, $650,000. Due for completion in June.

–Hydrogen test cell, $56,355. Due for completion this month.

–Addition to Guidance and Control Division building, $2 million.

–Addition to Fabrication and Assembly Engineering Div. building, $215,000. Construction contract in March.

–Addition to rocket checkout building, $4.5 million. Contracts in June.

–Expansion of Test Division industrial water system, $240,000. Contract to be let in February.

–Expansion of electrical distribution system, $579,000. Contract in May.

–Dynamic test facility, $609,000. Due for completion in March.

–Addition to buildings 4505-06, $2.5 million. Completion, January, '62.

–Vehicle maintenance building, $210,000. Contract award this month.

–Small construction, repairs, and alterations, $1.4 million.

Practically all the work on the schedule for Cape Canaveral is for *Saturn* facilities. Biggest item is for construction of *Saturn* Launch Complex 37, costing $20.8 million. Design contracts are to be awarded this month.

Other work at Canaveral:

–Completion of several parts of *Saturn* Launch Complex 34, $2.784 million. Includes hardstands for instrumentation sites, GSE installation, operations support building (contract to be awarded in March), and a liquid hydrogen system (yet to be designed).

–*Saturn* service tower escape system, $550,000. Design contract soon.

–Liquid hydrogen system for *Saturn* Complex 37, $2.5 million. Design contract due shortly.

–*Saturn* assembly and checkout building, $1.4 million. Design contract due in January.

–Addition to engineering and laboratory building, $300,000. Now in design; construction contract due in May.

–Engineering and operations building, $285,362. Completion in April.

–Modification to hangar for spacecraft preparation and checkout facility, $460,000. Now in design; construction contract expected this month.

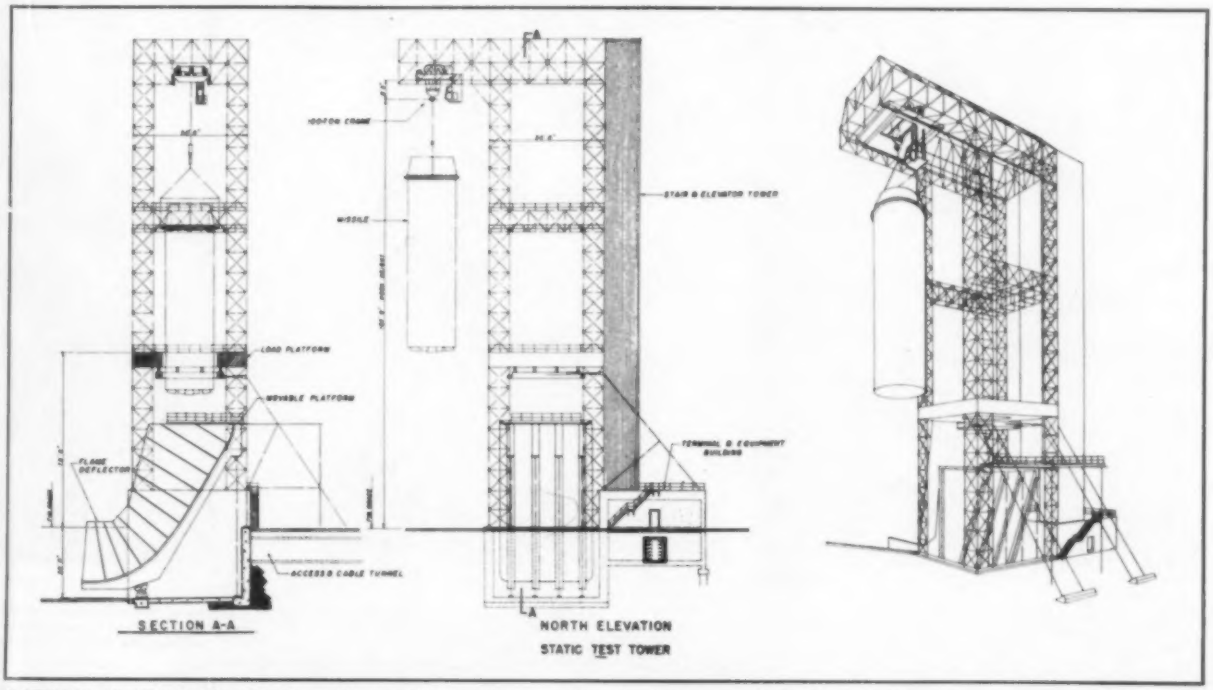
–*Saturn* service structure for Complex 34, $4.8 million. Scheduled for completion in April.

–*Saturn* Complex 34 pad and high-pressure gas system, $4.4 million. Due for completion in March.

–*Saturn* Complex 34 umbilical tower, $118,400. Completion in February.

–*Saturn* barge unloading facility, dock, and road, $170,000. To be completed in March.

–Modification to building to accommodate a computer, $39,900. Under construction. ⌗



SATURN STATIC TEST facility will cost $10.8 million, making it the largest single item in Huntsville construction budget.

POLARIS: Northrop's Datico checks out Polaris at all levels of maintenance and operation.

SKYBOLT: Guidance and navigation systems are being developed by Northrop for this new and highly secret air-launched ballistic missile.

MERCURY: The Northrop landing system is designed to bring the Mercury astronaut down safely.

HAWK: Northrop is a component [illegible] launching [illegible] base missile [illegible]

Northrop is now active in more th

X-15: Northrop produces Q-Ball, the flight angle sensor for safe re-entry of X-15 and other aerospace vehicles.

AERODYNAMICS: Northrop's Laminar Flow Control technique is designed to greatly increase aircraft range, flexibility, cargo and passenger capacity.

TITAN: Northrop supplies complete technical and industrial management to activate the T-2 Titan missile base [illegible]

FAR-SET MISSILE: Northrop is developing more [illegible] controlled surveillance [illegible]

Northrop Corporation, Beverly Hills, California • Divisions: Norair, Nortronics, Radioplane, Northrop International Subsidiaries

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landing sy**WK:** Northrop produces airframe
g the Mcomponents, ground handling and
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se missile.

COMMUNICATIONS: Northrop designs the trans-Pacific Scatter Communications Network and other world-wide communication systems for U.S. and free world governments.

T-38: World's first supersonic twin-jet trainer is built by Northrop for the United States Air Force.

rehan 70 important programs

s comple**GET MISSILES:** Northrop has pro-
nanagemeed more than 50,000 electroni-
issile base-controlled aerial targets, and
eillance drones.

COMMERCIAL METAL PRODUCTS: Northrop produces aluminum architectural shapes for many important industrial and commercial buildings.

SPACE RESEARCH: Northrop's accelerated space research programs reach into such advanced areas as maneuverability, rendezvous, space vehicle maintenance, space probes, and the survival of men in space.

ternation**sidiaries:** Page Communications Engineers, Inc., Acme Metal Molding Company.

Land-Air's White Sands Tracking

Pioneer in field utilizes 600 technicians, elaborate equipment to collect data

A $6.5 MILLION CONTRACT has been awarded Land-Air, Inc. for missile tracking instrumentation and services at the extended White Sands Missile Test Center and the Aeromedical Laboratory, Holloman AFB, N.M.; Arctic Test Center, Fort Churchill, Canada; and the Project *Mercury* Tracking Station, Corpus Christi, Tex.

The Army Ordnance Corps contract provides for engineering, research, development, instrumentation services and responsibility for data collection at the three sites. Equipment used includes cinetheodolites, tracking telescopes, high-speed motion picture cameras, telemetry, radar, electronic trajectory and miss-distance measuring systems, time signal generation and distribution, communications and closed-loop television.

Land-Air currently employs some 600 people in the installation, operation and maintenance of the range instrumentation systems and technical photo supports. Through its White Sands Holloman Division, the firm has participated in missile and test-vehicle tracking operations since 1949.

The prime function of the tracking experts is to collect information on what happens to a missile prior to and during its launching and flight.

• **Procedure**—On a typical mission, such as the 45-90 minute test launching of a *Matador*, fixed cameras are mounted around the launch area to provide initial trajectory, attitude and launcher data. Then low-speed cinetheodolites photograph the entire flight to provide trajectory data and telescopes record periodically to provide event data.

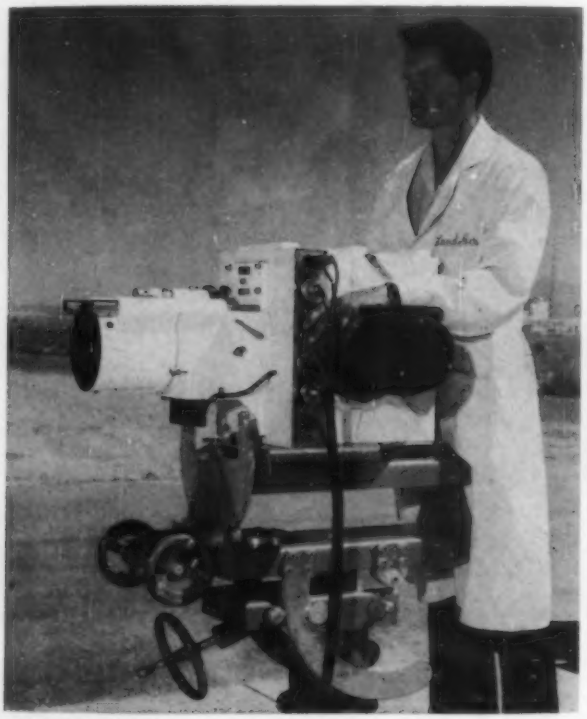
Equipment for nighttime ground test of a Hypersonic Test Vehicle would include cinetheodolites, fixed cameras and ballistic plate cameras. The cinetheodolites are to provide secondary trajectory data, fixed camera for launcher data and intial missile trajectory, and ballistic plate cameras for time of events and trajectory data throughout the flight.

For recording data on a high-speed sled firing on AFMDC's 35,000-ft. track, fixed cameras are used to cover selected portions of the track to provide space-time data. In this type of operation, a number of the ribbon frame cameras are placed perpendicular to the track so that adjacent cameras have overlapping fields of view. Engineering surveillance, time-history, attitude and slow-motion studies of high-speed events are provided by high-speed cameras placed next to the track or in the tracking camera towers.

• **Deceleration data**—In deceleration tests (see photo upper right), Land-Air technicians are responsible for the mounting of subjects on the sled, operation of the propulsion unit, data collection instrumentation, and for maintenance and other mechanical support. Ultra-high speed cameras are used to photograph subjects during these tests.

On the subject's right arm is placed a blood pressure device. A chest pack holds accelerometers which give measurements from which G forces can

TETRA (Terminal Trajectory Telescope) uses a Mitchell 70-mm camera to record flight, direction and final impact effect.



CLARK RIBBON frame-fixed camera provides data for time-history, attitude and other studies at Holloman sled track.

be determined. Wrist and ankle "bracelets" are attached for recording electrocardiograph information.

The 120-ft. decelerator under the present propulsion system accelerates the sled to a velocity of 50 ft. per second over a 40-inch length. Considering this maximum velocity, the present system is capable of subjecting objects and dummies to 100 g deceleration; however, the majority of tests are in the 60-70 g range.

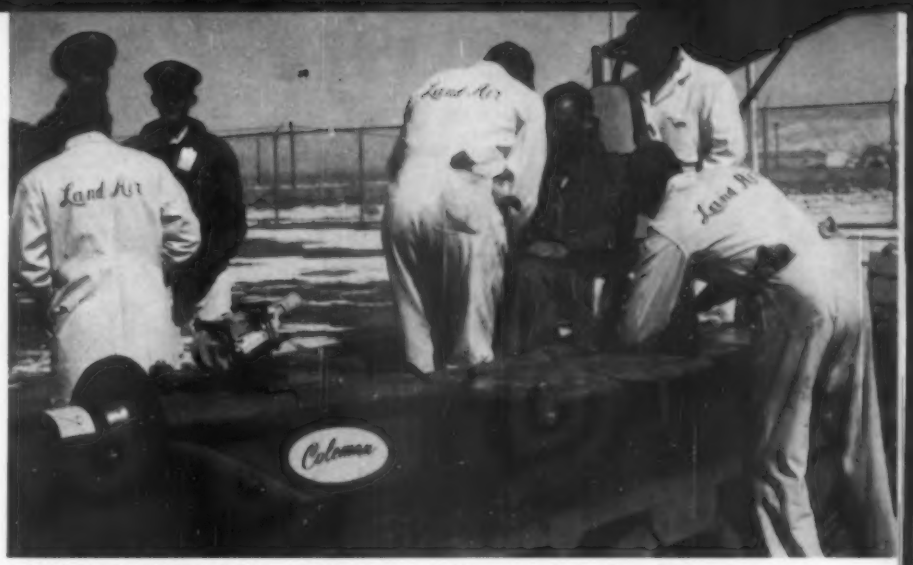
Other types of missions performed by Land-Air technicians include monitoring air-launched missile firings at balloon or parachute targets, ground-to-ground firings such as *Corporal*, and ground-to-air firings of *Nike* or *Talos* missiles.

After each mission is completed, the central control station takes a preliminary mission report from all of the stations consisting of test conditions, instrument operation, estimated time of coverage on each object such as the aircraft, missiles, and target.

On a maximum mission day, the Optical Measurements Group has exposed up to 30,000 feet of data film in the optical instrumentation equipment. The Land-Air group operates a multitude of various cameras on the range every day. These various instruments include 35 cinetheodolites to provide trajectory (position, velocity and acceleration), 13 permanent large telescopes and several mobile telescopes to furnish attitude, event, and precise miss-distance information.

The low-speed cinetheodolites are equipped with lenses from 20 inches to 118 inches focal length. The frame rate capabilities range from one per two seconds to 5 per second, with recording durations of 3 minutes to 30 minutes depending on frame rate. The high-speed cinetheodolites are equipped with lens focal lengths ranging from 60 to 180 inches. The frame rates obtainable are 10, 20, 40—with respective recording duration of 640 seconds, 320 seconds and 160 seconds.

Land-Air, Inc. is a subsidiary of California Eastern Aviation, Inc., Washington, D.C., and is a pioneer in the missile tracking field. It has designed and fabricated much of the complex electronic equipment utilized in the studies, some of which is capable of accuracies within two parts in one billion. ⌗



LAND-AIR TECHNICIANS attach instrumentation devices to test subject prior to deceleration. Fixed 35- and 70-mm cameras record results of sled experiment.

MODIFIED ASKANIA-WERKE cinetheodolite records trajectory, position, velocity and acceleration data from missile.

NEW MITCHELL telecamera uses a 30-in. primary mirror and 70-mm film to study missile behavior from launch to destruct.

Adaptable Swiss Aircraft Rockets

Oerlikon system based on tiny 'black box' fills needs of many European planes; weapons meet USAF specification standards

by Bernard Poirier

ROCKET STRIKE power, for troop support and aircraft defense, has been resolved for many European fighter and attack aircraft by Oerlikon's armament engineers in Zurich, Switzerland.

Their rocket weapons system grew from a requirement by several European aircraft manufacturers for a specific type of rocket fire power. The system would contain enough airborne weapons for repeated lethal passes at enemy strongholds during close troop support operations.

Oerlikon Machine Tool Works Buehrle & Co., whose constant development of modern arms often paradoxes the neutralist reputation of Switzerland, has merged rockets, launchers and electronic controls into a self integrated system which has been installed on Gloster Meteor and Venom jet fighters, the FIAT G 91 all-purpose NATO attack/fighter and on helicopters.

Rockets, guided missiles and bombs are easily adapted to the Oerlikon system. The company manufactures all components and offers a choice of warheads and selective-type controls which can handle two to one hundred-twenty rockets on one aircraft—all through an ingenious "black box" about 3x3x3 in. in size. This gadget is the Release Box which is an integral part of any combination selected for an aircraft rocket system.

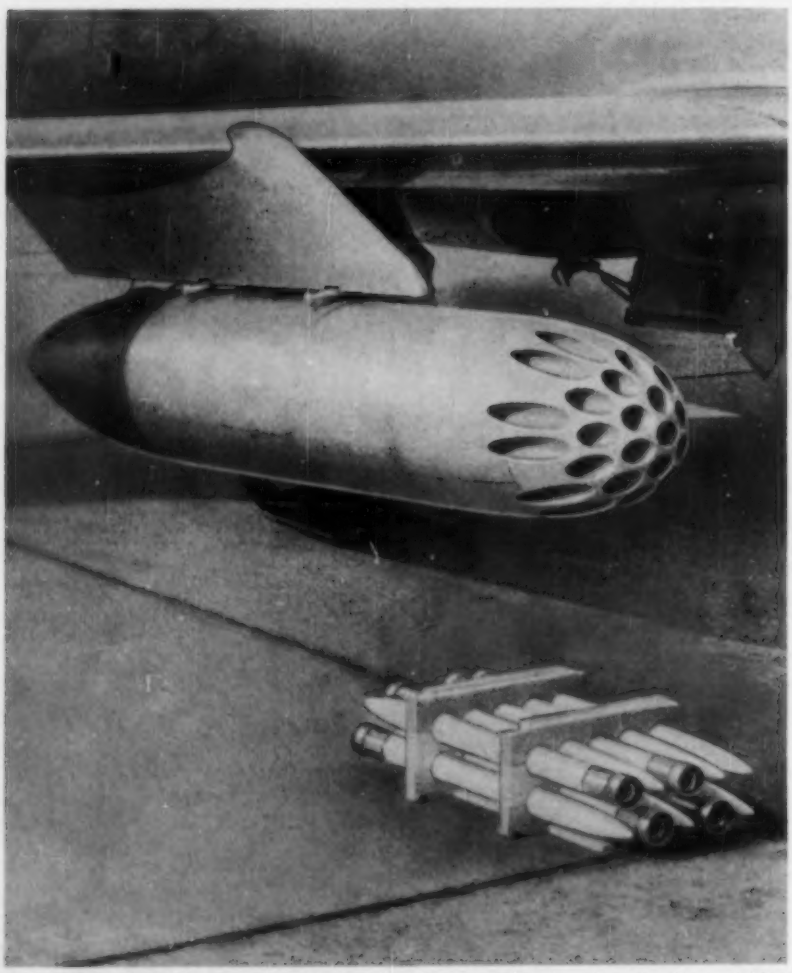
The most complete system includes fire button and main switch, single series and preselecting switch, shot counter, reset recording lamp and reset button, the release box, a nose wheel switch (for under fuselage rocket carriers) and a pre-fire check-out for the pilot.

To meet all eventualities as determined by specifications of various countries, Oerlikon has established quality controls and, in the case of one Italian customer, goes through 2000 switching actions and 8000 runs through the succession of selector contacts, without failures. During this time, the system is exposed to rapid changes within the range of operating temperatures, humidity and atmospheric pressures.

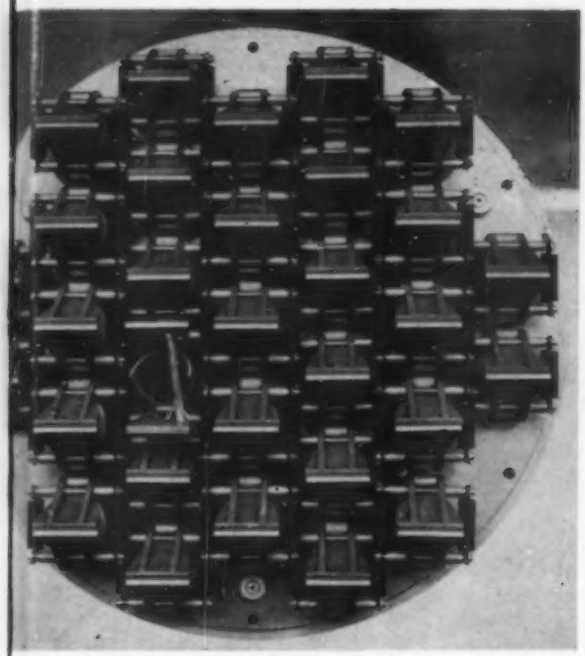
• **Attack mission determines size**—Oerlikon engineers fitted the system to military requirements. Two rockets of different strike power can be used, a 5 cm. size and the larger 8 cm. Each has characteristics which differ and offers certain advantages depending on whether a target might be an armored vehicle, train, artillery battery or an enemy aircraft.

Each has fins covered by a cylindrical cap which remains in the launcher at firing. This action compresses the folding fins which spring into position within a second of flight.

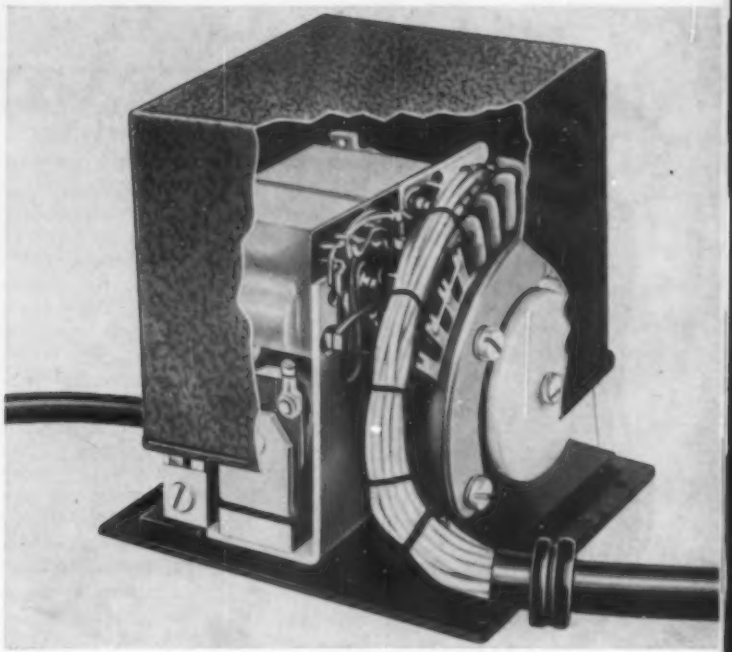
One foreign buyer demonstrated the system's killing power when an aircraft fired 72 five cm. rockets within 3.5 secs.



FIGHTER AIRCRAFT carries 31-round airborne rocket launcher for 5-cm folding fin rockets, which are electrically fired and controlled by the intervalometer.



REAR ENDS of launching tubes are closed by patented trap devices which open briefly to exhaust gases during firing.



OERLIKON ROCKET release box serves as control and release units for any type of aircraft rocket, measure only 3 x 3 inches.

in a dive starting at 3950 and ending at 1640 ft. Twenty-four direct hits on a 10x10 ft. target were registered after the diving attack. Dispersion in air-to-ground delivery averages 1% with deviation most pronounced on the vertical plane.

An electrical impulse triggers the ignition through a selective unit in the cockpit. Pairs of rockets can be fired at time intervals of .1 sec. or less. The 5 cm. rocket thrust in the first second is 450 lbs. with the fins opening at .012 sec. from the pod or launcher. In this time period the rocket traveled about five feet.

• **Automatic blast**—The safety range of the rocket's flight is a feature of the impact fuzed warhead or charge. It will not detonate in the first 65 feet even when penetrating metal three times as thick as metal capable of activating the explosive beyond this point in flight. Pyrotechnical destruction occurs automatically about six seconds after the rocket has traveled 170 feet. Total effective range is not given.

The armor-piercing shell with a hollow charge, featured particularly in the 8 cm. rocket but also available with the other, has a longer safety zone but the charge explodes instantaneously upon contact.

Fragmentation warheads, on the other hand, have the safety feature of the hollow charge and the pyrotechnical action of the impact fuze.

The firing and rocket release mechanisms have been designed with enough simplicity to be integrated easily with fully automatic controls which may be standard on an aircraft. They can also function with a radar aiming device for engagement of enemy aircraft.

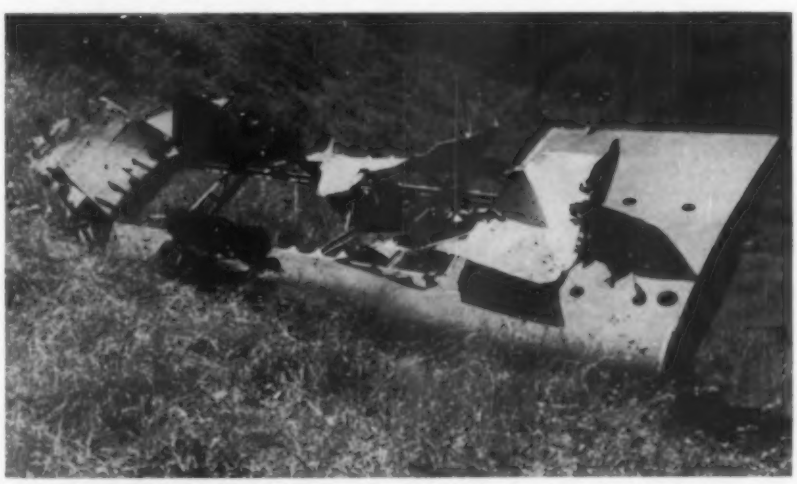
A pre-fire check-out can confirm reliability of the entire rocket load, over seventy, within a few minutes. The firing rate is as high as 1800 rpm or a maximum 1/15 sec. time interval for salvo pairs from twin pods.

Oerlikon has patented the trap device which releases exhaust gases briefly during firings and automatically closes to reduce aerodynamic drag. Contact pins are between the end of the launching tubes within a pod and the traps in the 31 rocket pod featured with the 8 cm. rocket.

This pod is suspended below the wings of an aircraft and the firing circuit has a intervalometer control which can be installed in the pylon or pod.

Oerlikon Machine Tool Works Buehrle & Co. has given its rocket weapons system notable prestige by conforming its techniques to USAF-type specifications as well as to particular needs outlined by its foreign buyers.

The company is quick to point out as well that, like Swiss watches and train schedules, there is little time loss between the pilot's reaction and rocket ignition. ⌗



THIS ALL-METAL WING was selected as a target for a passing-attack test of an Oerlikon 8-cm folding fin rocket. The results are apparent.

soviet affairs

by Dr. ALBERT PARRY

Giraffes as outer-space test animals

are now being used by Soviet space-medicine researchers. This is revealed by A. Klenov in the Moscow *Komsomolskaya Pravda* of December 2, in an article entitled "Astronauts, Get Ready! The Day Approaches . . ." The African mammal is chosen for acceleration tests because of his long neck, but not because—pardon the jest—the neck's length provides ample room for instrumentation during experimentation. The reason is explained by Klenov in these terms: When a man or any other animal is placed along a rocket's axis, and there is sudden acceleration, blood rushes either from his head to his feet or from his feet to his head, with equally bad and sometimes disastrous results for him. In particular, the man's (or any other animal's) heart cannot under such circumstances successfully pump the blood needed by his brain. But the giraffe's heart is naturally strong because it normally has to send blood all the long neck's way to his brain. Klenov writes: "It is as if the giraffe, although the earth is his habitat, were all the time flying in a rocket with acceleration." The object of the Soviet tests is most likely to discover how strong a heart-muscle system is needed by man before he can withstand his rocket acceleration as easily as does the giraffe.

Swine and bears are other test animals

mentioned in the same article. These have been used in Soviet space-medicine laboratories because, "insofar as their biological 'resistance of materials' is concerned, their bone systems have proved to be close to the same system in human beings." The Russian author notes especially the pig's "neck part of the spine" and the bear's pelvis bone. (For much the same reason, bears have been used by our Air Force experimenters in acceleration and deceleration tests in New Mexico, but in fast rides on sled-tracks rather than in rockets or balloons.)

The sea as a source of lithium

and other rare space-age metallic elements is envisaged for the Soviet in the near future by A. Davankov in his book *Volshebnyie Zerna* (Magic Seed), recently published by the Young Guard publishing house. The book is about ionites or "ion-exchanging tars," which according to the Russian writer are destined to play a remarkable role in man's economy when better technology of ionite exploitation is achieved. At one point in his book he describes a floating laboratory of tomorrow which, with hardly any crew or production staff (so complete will be its automation), will navigate the earth's seas and oceans to extract lithium among other space-age elements, all with the aid of ionites.

Experiments resulting in artificial lightning

are being conducted in the Energetics Institute of the Soviet Academy of Sciences by Doctor Ilya S. Stekolnikov and his assistant Ye. N. Brago. The article by N. Dobrovitsky in the Moscow *Trud* for December 14, describing these experiments, emphasizes the peaceful nature of Doctor Stekolnikov's successful work: "He reveals the laws of development of electrical charges and thus facilitates opportunities for their better application in people's economy." The new experiments also contribute to a better understanding, as well as to further improvement, of man's fight against the harmful effects of natural lightning: "Magnetic registers of an original type, made of a special alloy, within several years recorded nearly 1000 thunderclaps. Thus were obtained basic characteristics of natural lightning, needed for estimates of anti-lightning shields." No mention can be found in the article of earlier suggestions that the Soviets were interested in artificial lightning as a war missile. (For previous discussion of Russian experimentation with ball lightning, see SOVIET AFFAIRS, April 1958, page 136, and June 1958, page 159. Also see the article "Reds May Use Lightning as Weapon" by Donald J. Ritchie in M/R for August 24, 1959, pages 13-14.)

Langley Hydrodynamic Research Switched to Navy

THE NAVY HAS taken over and reactivated the hydrodynamic research facilities at Langley Field, Va., formerly operated by National Aeronautics and Space Administration. They will be operated as the high-speed phenomena division of the David Taylor Model Basin.

The newly established division will conduct research and development programs in high-speed craft and bodies such as hydrofoils, air cushion vehicles, hydro-skis, planing catamaran, STOL seaplanes, torpedoes, and underwater rocketry. Programs will be run for Navy's BuShips and BuWeps. Services will also be provided to NASA and private concerns.

Research programs scheduled include:

–Hydrofoils—Effects of impact, lift, drag and supercavitation; interference effects of foil flaps, etc.

–Ground-effect machines (Hydroskimmers)—Spray control, motion in waves up to fifty knots, ditching resistance, self-propulsion, etc.

–Development of 100-knot torpedo.

–Tests of underwater rocketry.

Tests will be conducted primarily in a large, indoor salt-water tank—2960 feet long, 24 feet wide, 12 feet in water depth—equipped with a wavemaker and a carriage capable of a speed of 50 knots.

The Navy will also have access to an outdoor fresh-water high-speed hydrodynamics facility (2180 x 8 x 5 feet) equipped with a carriage with a speed of 150 knots.

The Navy is responsible for the operation and maintenance of the facility, although the title to all buildings and equipment will be retained by NASA. The Division itself is physically located on property belonging to the Air Force.

AEC Moves to End Housing Shortage at Los Alamos

FIVE PROPOSALS for construction of a large-scale housing area near Los Alamos Scientific Laboratory have been received by the Atomic Energy Commission, virtually assuring much-needed housing for scientists working on numerous missile, rocket and space projects.

The shortage of housing at the New Mexico laboratory had been causing problems in the *Rover* nuclear rocket and other programs. (M/R, Aug. 1, 1960, p. 11)

In what has been considered a long-overdue move, AEC will select one of the bidding developers and negotiate a contract locally.

Harmonic Drive

(Continued from page 24)

friction characteristics of the drive. Thus, the drive is particularly well suited for tracking antenna and similar hardware in which, under certain operating conditions, the input speed is extremely low and output speed is almost indiscernible.

In the 40,000 to 1 drive, which is the largest transmission yet built, minimum backlash and high efficiency were also prime requirements. Estimates are that the Harmonic Drive principle is completely practical for ratios up to millions to one.

The unit shown in Fig. 5 is a good example. Developed for an airborne radar system, it is one of two Harmonic Drive transmissions that control the antenna position through a mechanical linkage.

Input to the drive is from a 10,000 rpm, 0.038 hp DC motor whose stall torque rating is on the order of 1 in.-lb. The stall torque from the transmission under these conditions is 85 in.-lbs., which is substantially greater than the capability of an equivalent-sized spur-gear unit. Its backlash is also considerably less: one minute or less, as compared with approximately 20 minutes for a spur gear drive. Because this unit was designed for missile application, light weight, compactness and reliability were parts of the specifications.

Possible Design Variations

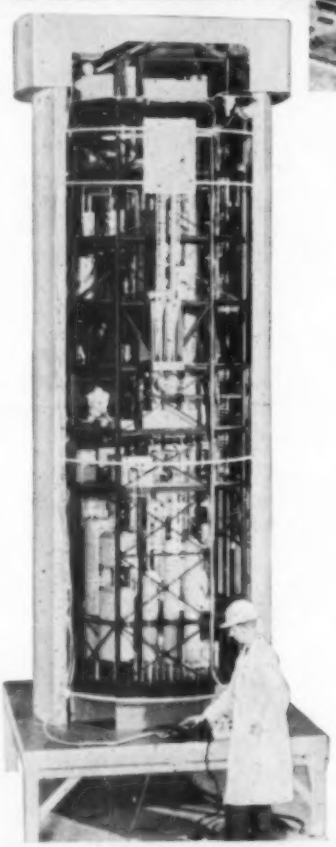
These are but a few of the transmissions that have been developed for military and missile applications. Others have been employed in commercial aircraft, such as the Boeing 707, and carried through the preliminary design stage for reducing the output from high-speed gas turbine engines for high-horsepower applications.

Another group is being used to transmit motion and power through the walls of vacuum apparatus, missile and space vehicles, and other sealed or encapsulated products. Still others have been developed for such products or apparatus as hoists, winches, machine tools, valves and positioning devices. In fact, about the only limitation developed to date is that in extremely small servo transmissions, such as those used for delicate motion transmission, inertia of the system may be higher than in conventional gearing.

The concept of transmitting motion through deflecting members is a completely new and heretofore neglected approach to the mechanical transmission of power or motion. It has already affected design and performance thinking in many missile and airborne systems, and is certain to have a far greater influence in the near future. ⌗

ASF–HAMMOND

Where Your Spring Design Problems Can Be Solved



• *America's finest spring plant is backed by over 50 years experience in solving spring problems.*

A full half century before the dawn of the space age, shock mitigation was already of major importance at ASF. Here, for example, was developed the ASF Extended Life® spring which more than doubles the life of railroad truck load-carrying coils. Countless other shock mitigation problems of the widest variety have been solved here with equal success. Among these many projects is the Atlas underground launching system (model shown at left) which makes extensive use of ASF shock mitigation devices.

No other organization in America today has a comparable record in this field. Why not investigate? Write today for complete information.

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G.I. to Get Easy Handling Tank Killer

ARMY'S NEWEST ENTRY in the tactical weapons field is the one-man rocket grenade LAWman. The light anti-tank weapon can be shoulder-fired prone (above), standing or kneeling (below right). The missile is aimed through a rear peep sight and a graduated sight imprinted on a clear plastic rectangle at the mouth of the launcher.

The darker portion of launcher tube is telescopic and can be pulled out to convert the 25-inch carrying case to a disposable launcher. Magnesium fins folded against the motor case when packed (below) stabilize the rocket in flight.

Hesse-Eastern Division of Flightex Fabrics, Inc., is prime contractor for XM72 LAWman. Some 25 Army elements and industrial organizations were involved in the project, with Army Ordnance Missile Command acting as system manager.

Minuteman Equipment Well Integrated

Inspection shows little variation in systems for mobile and hardened versions; a close look at how missile's G&C functions

THE FIRST development engineering inspection (DEI) of the full-scale *Minuteman* ICBM system showed few differences in equipment between the mobile and hardened configurations.

Airborne portions of the two systems are practically identical. Just as in the case of the hardened sites, *Minuteman* trainborne operational equipment (TOE) design has been dictated by requirements of the missile's guidance and control (G&C) system.

Computer-controlled, the G&C system has two basic requirements—a program of operation and instructions when to act upon program portions.

The system meets these requirements by integrated operation of its major components: the G&C coupler; the missile targeting and control console; and the digital printer and tape perforator console.

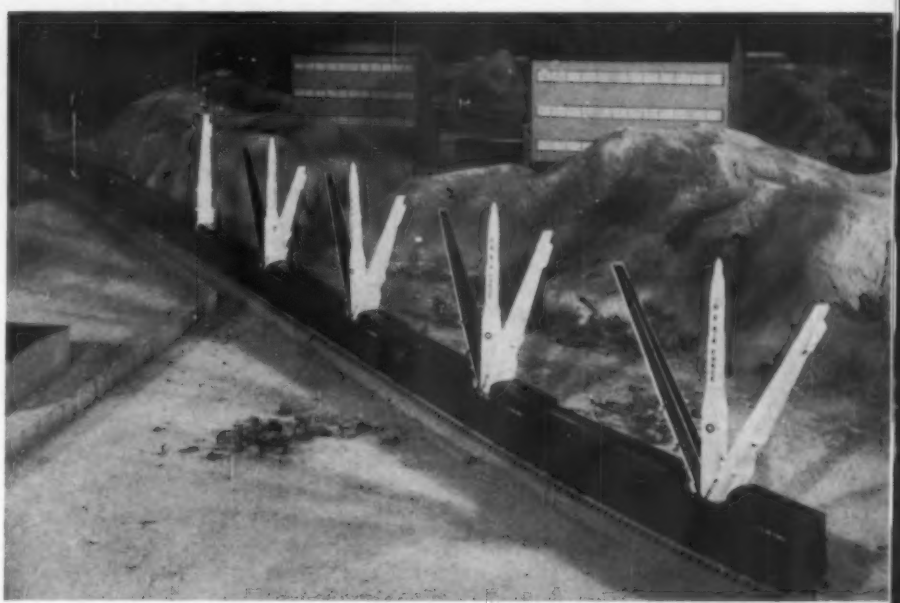
One requirement not directly connected with the G&C system is reentry vehicle fuzing. This information is supplied by the targeting and control console on special lines to the re-entry vehicle.

In the mobile *Minuteman* system the G&C coupler is the console electronically closest to the missile's G&C system. It couples all signals between missile G&C electronics and ground operational electronics.

• **Multiple chores** — Functionally, the G&C coupler will:

1. Transform all signals to the missile computer to a level acceptable to computer logic
2. Monitor all signals from the missile computer and, when necessary, transform these signals to a level acceptable to pertinent TOE logic
3. Transmit status information to various TOE units so state of system operation can be visually monitored
4. Synchronize operation of the computer and TOE by incorporating a precision clock
5. Act as a buffer between major system units to prevent ground loops.

• **Clock & back-up**—The precision clock provides signals for the coupler, the D17 missile computer, and the sequencer and monitor. The signals are available in sub-multiples of 1 mc to approximately 1 cps. Signals at about 4 kc are available for coupler use at phases of 0°, 90°, 180° and 270°.



MINUTEMAN TRAIN MODEL shows missile in "strategic alert" position, with strongback covers open. In actual operation, covers open seconds before launch.

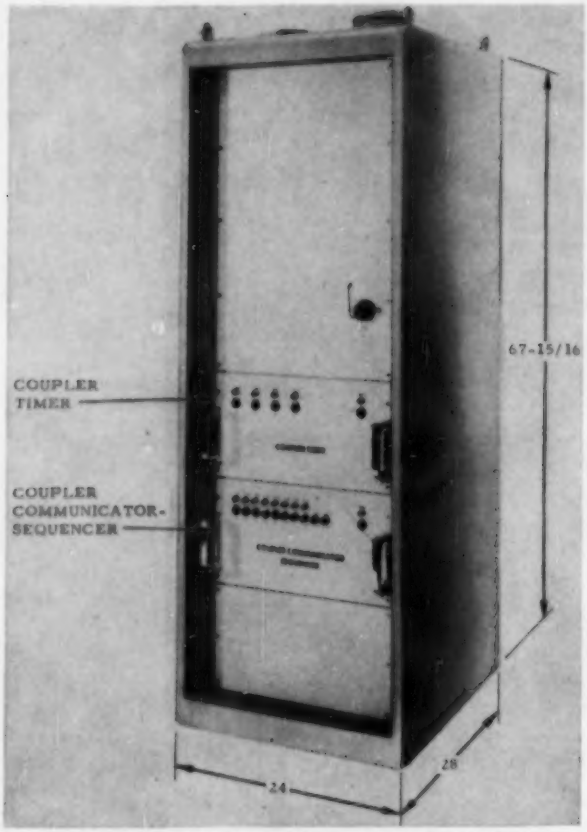
The clock's frequency generator is a 1-mc crystal-controlled oscillator accurate to 1 part per million. Its accuracy may be degraded to 10 parts per million after three years of operation. Associated with the oscillator is a serial counter which increases the period time from 1 sec. to 1.048576 sec.

A back-up oscillator is provided in case of failure. This standby unit generates a 15.6 kc signal with an accuracy degradation of not more than 5% over a three-year period.

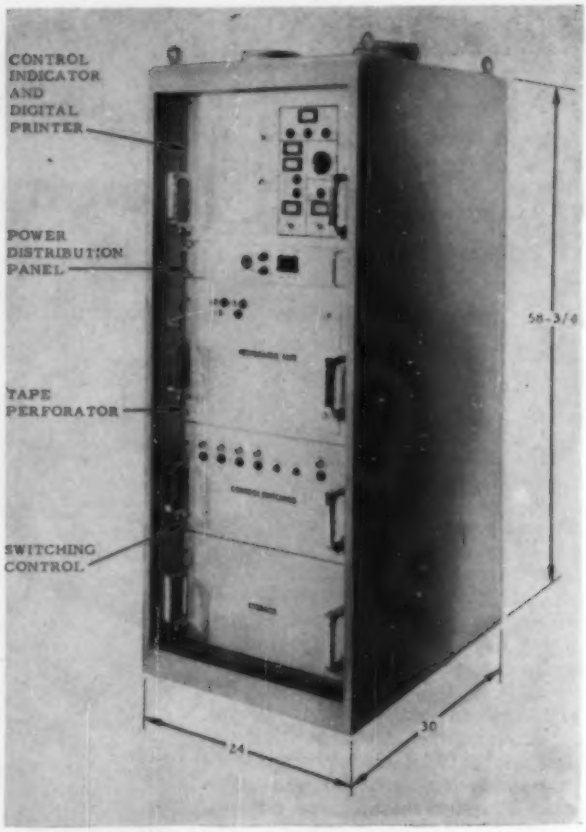
The precision clock provides the airborne missile computer with a clock pulse of 512μ sec. pulse width and a repetition rate of one pulse every 1.048576 sec. It also provides the sequencer and monitor with a symmetrical square wave at the same repetition rate.

• **Receiving commands**—A mode controller is included in the G&C coupler to receive discrete commands from the missile alinement set or from the sequencer and monitor. Commands are gated so the output will set up correct codes in the mode register. Mode controller outputs are sent to an encoder for use in coincidence checks. The mode register, through inputs for the controller, sets the G&C coupled in a particular state of operation. It also supplies a mode characteristic code to both the coincidence detector and output confirmer.

Discrete commands from the G&C coupler, azimuth alinement set, and the coupler's mode controller are received by the encoder. Following encoding, commands are sent to the coincidence detector via the computer in-



MOBILE MINUTEMAN Trainborne Operational Equipment (TOE) includes guidance and control coupler console.



DIGITAL PRINTER and Tape Perforator console of mobile TOE selects and receives information from five G&C sets.

formation receiver and used for checking coincidence between the input command and the resulting state of the mode register.

The computer information receiver provides pulse shaping and logic conversion of the computer output characters so they can be handled by the decoder and the coincidence detector, or by the targeting and control console.

Coded information from character output lines of the computer is received by the decoder and transformed into discrete outputs. Codes detected by the decoder are Sequence Advance, General Acknowledgement, Flight Mode Entered, Data Readout, Upstage No-Go, Downstage No-Go and G&C Alarm. No-Go and Alarm codes are sent to the error detector. Other codes are used to control the sequence timer and coincidence timer.

The coincidence detector verifies that the G&C coupler and the missile computer are in the same mode. Mode characteristic codes from the mode register in the G&C coupler are compared with mode confirming codes from the computer. A discrete output is issued to the coincidence timer if the codes are identical. The coincidence detector also verifies that the mode register is set properly before any command is issued to the missile computer. This is accomplished by comparing the input command from the decoder with the states of the mode characteristic from the mode register.

Controlled by the precision clock, the coincidence timer will, upon command, open a coincidence gate for 1.5 sec. If a coincidence signal is not received during this period, the error detector will detect a sequence error.

• **Timing provision**—During normal operation, several sequences require timing. This is accomplished by a sequence timer consisting of a counter and a diode matrix. The timer is set by a specific output signal from the output confirmer. At the end of the timed period, the sequence timer will expect a sequence advance from the decoder. If the advance is not noted at the proper time, the error detector will detect a sequence error. By this arrangement, coupler modes will be synchronized with computer modes.

The error detector recognizes Upstage No-Go, Downstage No-Go, Sequence Error and Coupler No-Go. It stores error information and sends discrete outputs to the output confirmer. When an error is detected, the coupler causes the computer to be reset and its discrete outputs to be disabled.

States of the mode register and error detector control the output confirmer. The latter sends system status information to the targeting and control console and the sequencer and monitor, indicating the status of the G&C coupler and missile computer. The output confirmer also issues the proper timing references to the sequence timer.

Computer discrete amplifiers receive character input codes from the tape programer of the console and transform the signal characteristics to a level acceptable to the computer.

• **Role of console**—A second major piece of the TOE system is the missile targeting and control console located electronically between the digital printer and tape perforator console and the G&C coupler. This console provides the following to the G&C system: (1) loading of the computer program; (2) manual control of the program; (3) visual monitoring of the program status; (4) electrical linking of the G&C coupler and the digital printer and tape perforator console; (5) furnishing fuzing instructions directly to the re-entry vehicle; and (6)

supplying power directly to the computer memory cold-storage write amplifiers when loading the program.

Basic sub-components of the targeting and control console are a tape programer, a control-indicator panel and four standard drawers of electronics.

Function of the tape programer is to transport and read out a punched mylar tape. It has capabilities of high-speed forward and reverse operation (slew) and, in conjunction with the tape programer controller, the capability of transporting tape up to and stopping at a predetermined code word on command (search). A photoelectric detector is used to read a standard eight-hole-per-frame tape. A ninth hole, the sprocket hole, is used to generate a timing pluse with every frame read.

The tape programer has a normal reading speed of 200 frames per second and a slewing speed of 600 frames per second. A single transverse column of eight code holes, plus one sprocket or timing hole, is read as a single word to produce five data bits, a timing bit and three steering bits.

There are two major parts of the tape programer controller which decode and gate tape programer output signals—a decoder and a tape controller.

The decoder operates separately on the five data bits and three steering bits read by the tape programer. The decoder gives 16 discrete outputs for the five data bits and eight discrete outputs for the steering bits.

The tape programer controller is sensitive to certain combinations of steering and data discretes, and thus controls the destination of information read from the tape. Certain combinations will send the resulting data bits to the missile computer; the fuzing mechanism; the digital printer and tape perforator console; the control-indicator panel of the targeting and control console; and, internally, in the latter console to execute and control other phases of the pre-punched program.

The tape controller combines signals from the decoder with manually initiated command signals to activate various modes of the tape programer. Manual tape control modes include Search-Forward and Reverse, and Slew-Forward and Reverse.

• **T&C panel**—Operating station for the targeting and control (T&C) console is the control-indicator panel from which the operator can control the console and, in turn, the computer program. The operator also is able to monitor G&C system status visually and continuously.

A coupler is associated with the panel to receive signals from the G&C coupler and tape programer controller, and to provide driving power to display these signals as status information.

The T&C console contains two command signal programers designated No. 1 and No. 2.

The No. 1 unit provides a controlled communications link between the G&C coupler and the digital printer and tape perforator. Four information channels are furnished: (1) tape output—input to this channel is from the tape programer; output may be switched to either the digital printer and tape perforator or to the missile computer via the G&C coupler; (2) Computer Output—inputs to this channel are character outputs of the missile computer; output is to the digital printer and tape perforator console; (3) Control—inputs are manually initiated command signals from the control-indicator panel; commands are sent to G&C coupler for program control; (4) Status—inputs are status signals from G&C coupler; outputs are to control-indicator panel coupler.

Command signals programer No. 2 provides a controlled link for decoded fuzing information between the tape programer and the re-entry vehicle. Fuze-setting process is monitored by verification signals from the re-entry vehicle received by the No. 2 programer. If verification signals are not received, a fuzing error is displayed on the control-indicator panel and the tape programer is stopped.

The No. 2 programer also contains the Enable Write power supply which is used when filling the missile computer from the tape programer.

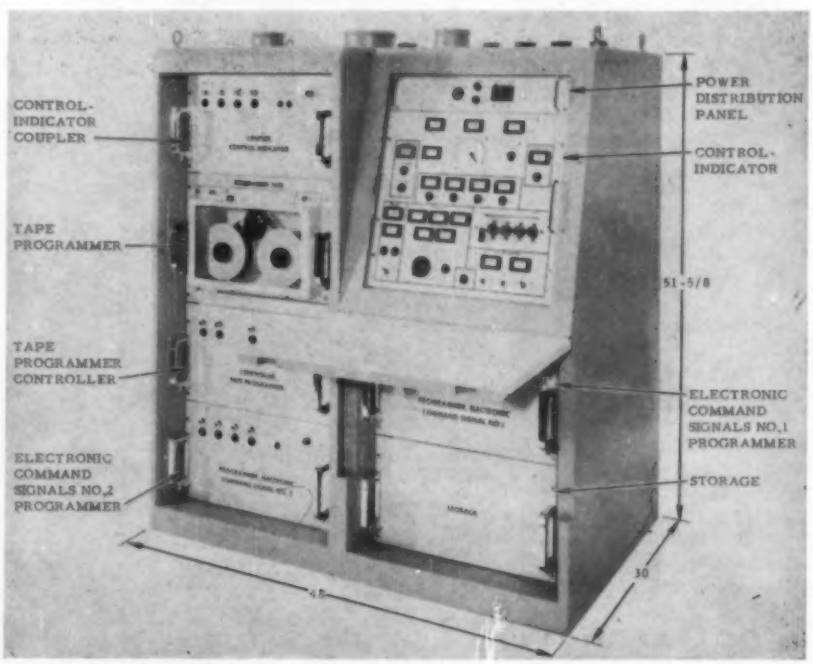
An error detector continuously checks the five data bits read from the tape for "odd-bit" parity. If a parity error is detected, the tape programer is stopped and a tape programer No-Go signal is displayed on the control-indicator panel. Odd parity of the five data bits is also checked at the decoder output. In this case, however, detection of parity error will stop the tape programer and transmit a console No-Go signal to the display panel.

The command car of the *Minuteman* mobile system will contain a third major component of the TOE—the digital printer and tape perforator console. With this unit, information can be selected and received from any one of five missile G&C sets.

The console consists of a tape perforator, a control-indicator panel and two drawers of electronics. It provides capabilities to: (1) print or punch on tape results of missile guidance set calibration upon command; (2) print results of missile velocity meter bias cycles upon command; and (3) print target azimuth angle and fuze-setting information from the targeting tape by the targeting and control console.

The control-indicator panel, like the targeting and control console layout, is the operating station from which the operator can monitor and control the console as well as select any one of five external system from which data may be received.

The digital printer provides auto-



MISSILE TARGETING and Control Console in TOE system consists of a tape programer, a control-indicator panel and four standard drawers of electronics.

Spincraft experience in space can mean down to earth savings for you...

Spincraft, with over a decade of missile experience, was a natural supplier for contractors on two recent rocket projects. One, the IRIS, was large; the other, NIKE CAJUN, was small.

Only Spincraft's kind of experience and equipment could fashion these tapered aluminum cones to the exacting tolerances required. Therefore, Spincraft's unique skill is constantly being applied to the solution of unusual metal-forming problems.

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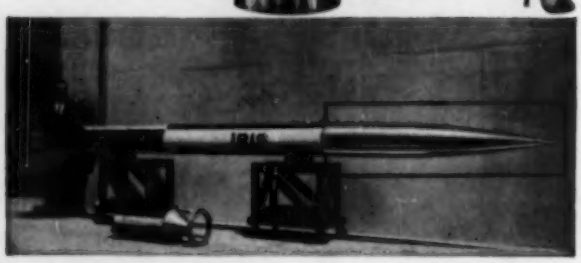

Write for Notes For An Engineer's File, a series of valuable bulletins.

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matic, high-speed, permanent recordings of data from an external system. It is capable of parallel entry and prints a line of 10 symbols simultaneously (alphabet or numeric), utilizing 13 columns of paper tape. One-line print out and paper advance will occur in 166 ms, giving a print speed of six lines per second.

The tape perforator portion of the console is capable of punching a complete line, composed of eight code holes and a sprocket hold, selecting a code hole and advancing the tape in 40 ms. It can also continuously punch a minimum of 20 characters per second. The perforator receives characters from its own electronics section which receives character inputs from the missile targeting and control console. Characters to be punched are stored during each punch cycle. When they are punched, memory devices are reset.

Incorporated in the console is a sequencer (binary counter) which receives timing pulses and counts to 10 during normal operations—to 18 during self-test.

A decoder unit decodes the first and last characters of each information word received. It also converts binary coded decimal outputs from the sequencer to decimal discretes from 2 to 10. The discretes channel the character of the information word to their designated places within a register.

The register is a memory device that stores the data word to be printed. It handles two types—an information word or a computer error word.

An odd-parity check is made of all character inputs to the digital printer and tape perforator console. A parity error lamp will light on the control-indicator panel if such an error occurs.

Final unit of the TOE is the DC portable power supply which provides overvoltage to the missile for starting the G&C set, gyros, fan and memory disc. The set consists of a rechargeable battery pack, a voltage divider and a recharging circuit. Upon command from the sequence and monitor console the unit puts out 40 to 45 volts DC for 2 to 2.5 seconds, after which a second command terminates the voltage. The DC package is capable of 10 cycles over a 10-day period without recharging, and 10 recharging cycles before replacement of the battery pack.

Guidance and control test equipment is nearly all automatic and is quite similar to that of the silo-based *Minuteman* system. It provides Go, No-Go information which, in conjunction with the programing test set and the ground electronic test group, performs system tests at overall and/or subsystem level. ⌗

Circle No. 11 on Subscriber Service Card.

Army Readies Huge Test Building

THE ARMY WILL be able to subject entire missiles to global environments with the completion of a $3-million-plus Preflight Building at Redstone Arsenal, Huntsville, Ala. early next spring.

The facilities are part of the Army Rocket and Guided Missile Agency's Test and Evaluation Laboratory. Specimen chambers are available for high and low temperatures, temperature shock, humidity, salt spray, vibration, fungus resistance, sunshine, rain, and sand and dust tests. The chambers are constructed in accordance with Mil-E-5272C.

This specification establishes generally applicable procedures for testing aeronautical and associated equipment under simulated and accelerated climatic and environmental conditions.

Each of the major test cells opens to a track-mounted crane assembly. Overhead hoist beams in each of the cells allow a complete missile or other test specimen to enter and withdraw swiftly. The only exception is the sand and dust chamber, where the specimen is mounted on the chamber door and then swung into the cell as the door closes.

The test area has heavily reinforced walls with blowout roofs and doors on each of the chambers. Thus the facility can accommodate hazardous items.

Designed by Ralph M. Parsons, Los Angeles, and constructed by Pierce & Gresham, Decatur, Ala., the building is already staffed and in limited use.

SUNSHINE CHAMBER subjects missiles to radiant energy generated by these banks of lamps. The stainless-lined cell can handle a 35-ft. weapon.

The prime equipment contractor is Technical Constructors, of Dallas.

• **Varied environment**—A 25,000-force pound electromagnetic shaker with a frequency range of 5 to 2000 cps is mounted in the main vibration cell. In addition, the Preflight Building will house five other shakers of various sizes in the two vibration cells. Both cells will have temperature controls.

Missiles up to 30 ft. in length and 8 ft. in diameter can be subjected to rain and salt spray tests in another cell. The rain rate can be varied from 4 to 12 in. per hour with variations in direction up to 45°.

The facility has a sunshine cell capable of flooding a 35-ft. missile with radiant energy at the rate of 100 to 140 watts per square foot while maintaining the temperature at 113°F.

Six simultaneous static or dynamic loads up to 100,000 lbs., either in tension or compression, can be applied to specimens as large as 60 x 72 x 240 in. and weighing 40,000 lbs. in the multi-component structural test chamber.

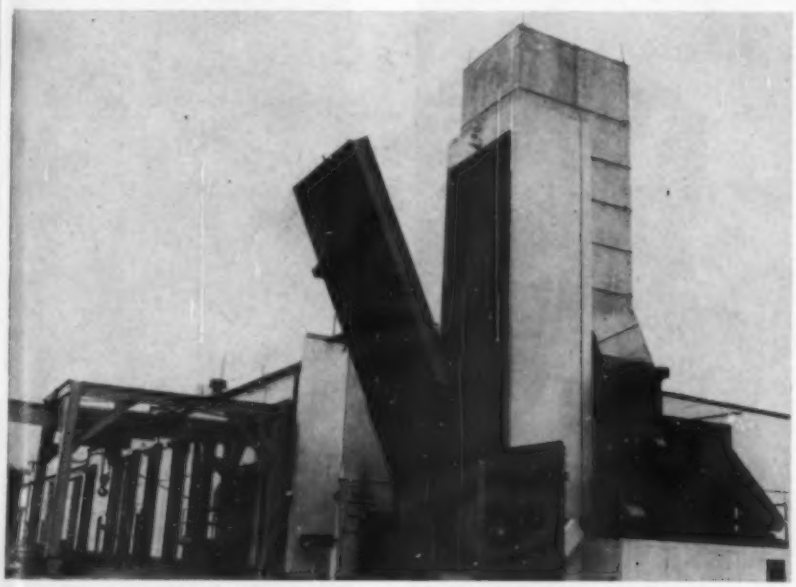
Two cells house X-ray equipment. A 150,000-volt system is currently available for inspections and a 22-million volt Betatron is planned. Cobalt 60 gammagraph equipment is available, along with ultrasonic, magnetic particle and dye penetrant systems.

Test items up to 24 feet in length and 5.5 ft. diameter will fit in the sand and dust chamber. Wind velocities from 200 to 2300 ft./min. are possible. Sand and dust size and concentration can be varied from 1 to 1500 microns and from 0.0001 to 1.0 grams/cu. ft.

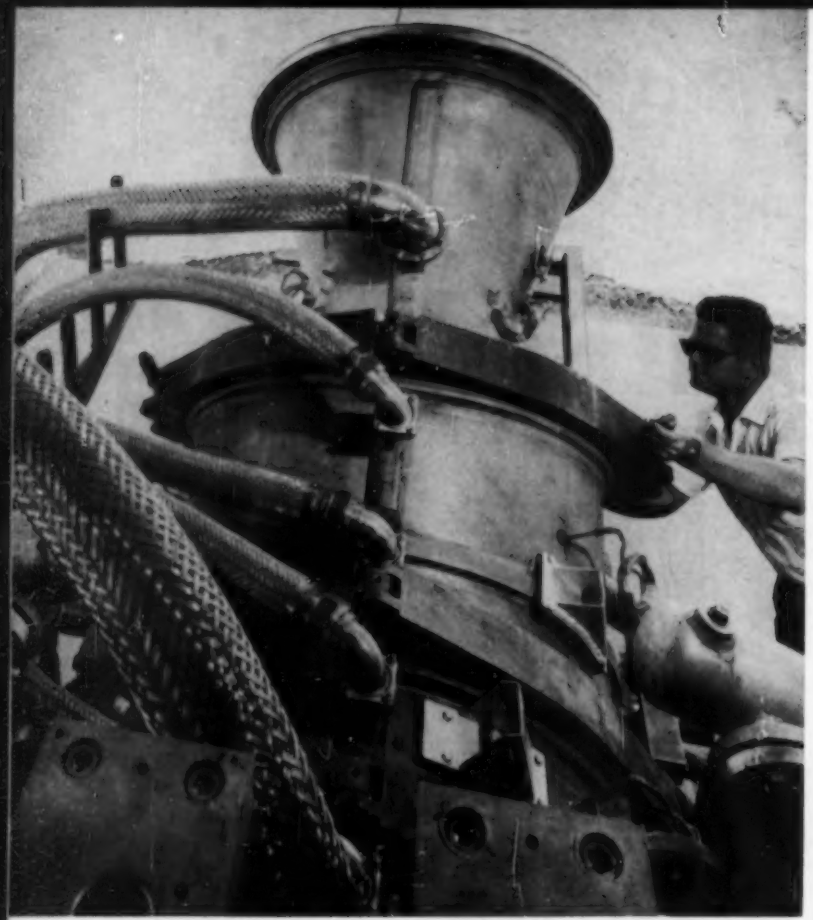
Smaller cells simulate altitudes up to 100,000 ft. Other, similar sized chambers handle shock tests, accelerated and long-term storage tests. A 5400-gal. immersion tank is available.

Physical measurement facilities are included in the Preflight Building and future plans envision a remote controlled drop test, a sustained acceleration test and an acoustic noise test.

The Preflight Building is the newest of the complex of test facilities operated by ARGMA and will be available for use by any government agency or contractor for tests associated with development of missile systems or system components. ⌗



TEST ITEMS ARE MOUNTED on the sand and dust cell door, then swung into the chamber. Specimen loading crane has access to each cell along side of building.



TORY 88A TEST TRACK is nicknamed "Jackass and Western Railroad."

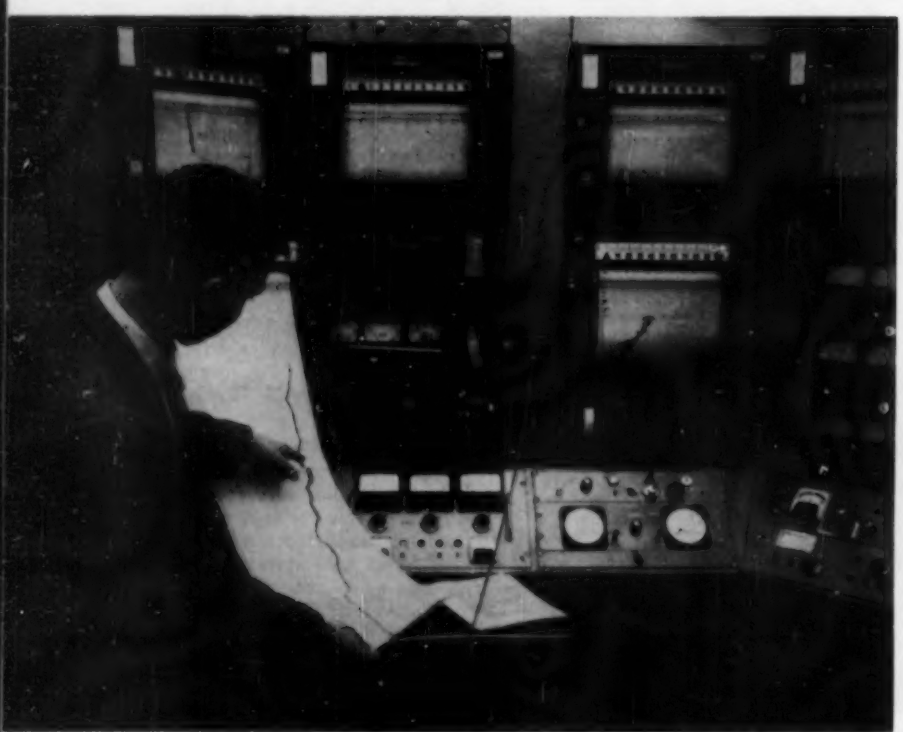
propulsion engineering

Tory IIA Gees

TESTS TO BRING the Tory IIA-1 reactor up to full power are now in progress at the AEC's Lawrence Radiation Laboratory at Jackass Flats, Nev. The reactor, being designed for the Air Force-AEC *Pluto* nuclear ramjet, went critical for the first time on Dec. 9. Full power design is about 150 thermal megawatts. The reactor is expected to produce about 5000 to 10,000 lbs. thrust, although program scientists are not attempting now to reach these levels. The reactor unit shown here is backed up by Tory IIA-2. The core for the second unit is being produced by Atomics International.

No military requirements as yet exists for *Pluto*. But the ramjet is the most likely one to power a supersonic low-altitude missile—SLAM—should this be decided upon as the best method of getting in under enemy radar defenses.

Photos by Aerojet-General and Frank G. McGuire



DATA IS RECORDED during a cold-flow run of the test unit.

COOLING LINES give the reacto

ests Aimed at Full-power Operation

At present progress levels, it is believed a flying version of a *Pluto* ramjet vehicle could be produced by 1965. The Mach 3 vehicle would be capable of sustained flight for three days. Cruising over ocean or desert, it could be directed to a pre-selected target on command. The unmanned bird would have a large payload capacity—perhaps up to one-quarter of gross weight. Thus it could carry a 20-megaton or bigger warhead. Operating altitude of such a missile would be at a relatively constant 1000 ft. or other low level.

Core (lower right) contains fuel elements of enriched uranium and beryllium oxide. There are more than 100,000 elements in the core measuring 30 inch by 45 inch. Nickel alloy tension rods are mounted between interstices, providing longitudinal support and medium for water coolant.

SPARE NOZZLES for test unit sit outside the assembly building.

arance of an old-time fire engine.

CORE HAS MORE than 100,000 uranium and beryllium oxide fuel elements.

names in the news

TITUS

HENNESSY

INTO

GILLETTE

HOGAN

David W. Pertschuk: Appointed Director of Reliability and Quality Control at the Precision Products Dept. of Nortronics. Prior to joining the firm, he was responsible for all reliability activities and procedures at Arma Division, American Bosch Arma Corp.

Lee Hennessy: Former market research and development engineer for Rogers Corp., joins Industrial Electronic Rubber Co. as technical director responsible for management of the materials development and material quality control.

Theodore E. Borque: Joins Consolidated Diesel Electric Corp. as senior project engineer directing design and development of new types of gas turbine-powered ground support equipment for aircraft and missiles. Was formerly a project design engineer with General Electric Co.

Ted Candee: Former staff assistant, named manager of the Procurement and Contracts Division of the California Institute of Technology's Jet Propulsion Laboratory.

M. A. Benanti: Joins Precision Circuits, Inc. as an electronic engineer, with responsibility for extending the Molecular Electronics line of semiconductor test equipment.

Charles K. Titus: Former director of the digital computer laboratory at the Air Arm Division of Westinghouse Electric, joins the staff of the Communication and Data Processing Division of Collins Radio Co. as manager of the scientific analysis and programing department.

Kendell Oulie: Former assistant to the director of planning named director of planning for The Garrett Corp., replacing **John W. Calvert,** now manager of marketing services.

A. Norman Into, Jr.: Formerly marketing manager, Communication and Navigation Equipment in RCA's Airborne Systems Division, joins Rese Engineering, Inc. as director of marketing.

Pierre A. Portmann: Promoted to the office of assistant director in the Research and Development Directorate of Page Communications Engineers, Inc. Was formerly senior staff engineer in the R&D Directorate.

James L. Fouch: Former general manager of Microsound, Inc., named executive vice president of Calibration Standards Corporation.

Jack Gillette: Appointed associate director of engineering for Standard Rectifier Corp. Was formerly chief electronics engineer for Hughes Aircraft Co.'s Semiconductor Division.

Orien L. Hogan: Former chief of applications engineering, appointed senior representative at Huntsville for Rocketdyne, a division of North American Aviation, Inc., replacing **D. H. Stewart.**

Phillip V. Aronson: Named sales manager for The Raytheon Co.'s Airborne Products, Submarine Signal Operations.

Michael J. Marino: Former advertising manager, named marketing manager of International Resistance Co.'s Major Industrial Distributor program.

Richard J. Stone: Former projects leader in the Research Division of the Curtiss-Wright Corp., joins Corning Glass Works as research and development supervisor in the delay line section.

Frank H. Bower: Appointed to the newly-created post of manager of research and development contracts for the Semiconductor Div. of Sylvania Electric Products, Inc.

R. L. Bentley and **R. P. Conniff:** Appointed assistant to the vice president of marketing and manager, re-entry vehicle sales, respectively, for Avco Corp.'s Research and Advanced Development Division.

George E. Spaulding, Jr.: Former director of research and general manager of the SPARD division of Electric Autolite Co., joins Bell & Howell Co.'s Photo Products Division as vice-president in charge of engineering operations.

Howard P. Mason: Former corporate base manager at the Pacific Missile Range for Aerojet-General Corp., named manager of the company's Washington, D.C., office.

William M. Prull (USAF-ret.) Joins the Advanced Systems Research Dept., Military Systems Division of Lockheed Electronics Co. as an operations analyst.

Andrew J. Myers: Former quality manager for the Boeing Airplane Co., joins The Martin Co.'s Denver Division as manager of Quality Control Fabrication.

Rubin Blumkin: Elected vice-president, engineering, at General Restance, Inc. was formerly chief engineer.

C. F. Pizac: Former manager-sales, named director of marketing for the Electronics and Avionics Div. of The Emerson Electric Mfg. Co.

George M. Cooley and **Ronald D. Curtis:** Appointed senior analytical engineer and senior project engineer, respectively, for The Fafnir Bearing Co. Cooley, prior to joining the firm in 1956, was a research engineer with United Aircraft Corp.; Curtis came to Fafnir in 1956 from the Bristol Machine Co., where he was a designer and project engineer.

W. A. Smith: Manager of new product sales for B. F. Goodrich Industrial Products Div., named manager, marine and ground support equipment, for B. F. Goodrich Aviation Products.

Denham Scott: Assistant to the president, The Garrett Corp., appointed an associate member of the Military Procurement Advisory Committee to the U.S. Senate.

contracts

NASA

$216,210—**Electronic Associates, Inc.**, Long Branch, N.J., for centrifuge conversion computer.

$75,000—**Ryan Aeronautical Corp.**, San Diego, for development of methods and techniques for high-energy forming of hemispherical and cylindrical shapes involved with space exploration programs.

NAVY

Laboratory For Electronics, Inc., Boston, for design, documentation and prototype production of analog computer modules for use in *Polaris* submarines. Subcontract from **General Electric Co.'s Ordnance Dept.**

$8,300,000—**Westinghouse Electric Corp.**, Pittsburgh, for additional production of the radar portion of the air missile control system for the F4H-1 fighter plane.

$4,941,573—**Lockheed Aircraft Co.**, Burbank, Calif., for installing Julie-Jezebel detection equipment on 69 Neptune antisubmarine aircraft.

$2,500,000—**Raytheon Co.**, Waltham, Mass., for continuation of industrial support to MIT in design and development of the *Polaris* inertial guidance system.

$110,000—**The Siegler Corp.**, Hufford Div., El Segundo, Calif., for ground support equipment components for the *Terrier* anti-aircraft missile.

MISCELLANEOUS

Jet Propulsion Laboratory has awarded study contracts to investigate the feasibility of building an advanced space tracking antenna 200 to 250 ft. in diameter to: **Blaw-Knox Equipment Div.**, Pittsburgh; **Hughes Aircraft Co.'s Ground Systems**, Fullerton, Calif.; **North American Aviation, Inc.**, Columbus, Ohio; and **Westinghouse Electric Corp.**, Pittsburgh. Amounts not disclosed.

AIR FORCE

Cohu Electronics, Inc., Kin Tel Div., San Diego, for an undisclosed amount to supply closed-circuit television systems to be mounted in *Atlas* launch complexes at Vandenberg, Offutt, Warren and Fairchild AFB's.

RCA, a "multi-million dollar" contract for the development of a complete communication subsystem for the *Dyna-Soar* test program.

Espey Mfg. & Electronics Corp., Saratoga Industries Div., Saratoga Springs, N.Y., for 18 battery charger power supply units to be used to operate the underground *Titan* launching system in event of electric power failure. Subcontract from **The Martin Co.**

Foto-Video Electronics, Inc., Cedar Grove, N.J., for production of a closed-circuit color television system. Amount not disclosed.

Chance Vought Corp.'s Astronautics Div., Dallas, for developing the nose cap for the *Dyna-Soar* man-carrying space vehicle. Amount not disclosed.

$3,210,874—**Eclipse-Pioneer Div., The Bendix Corp.**, Teterboro, N.J., for aerno compensators, converters and computers, spare parts, ground support equipment and data.

$2,000,000—**Minneapolis-Honeywell Regulator Co.**, for design, development and production of flight control electronics for the *Dyna-Soar*. This is in addition to a previous $2,700,000 for development of an inertial guidance system.

$379,205—**Boeing Airplane Co.**, Seattle, for technical data applicable to the *IM-99* missile. (Six contracts.)

$277,433—**General Dynamics Corp.'s Convair-Astronautics**, San Diego, for emergency sub-chassis for Azusa Mark II.

$200,000—**General Atronics Corp.**, Philadelphia, for research and development studies.

$147,803—**Douglas Aircraft Co.**, for study of exhaust heat trails by rockets launched from Cape Canaveral over the Atlantic Missile Range.

$140,000—**Ford Motor Co.'s Aeronutronic Div.**, Newport Beach, Calif., for investigating semirigid and nonrigid space structures for use at extreme altitudes.

ARMY

$28,895,115—**Hardaway Contracting Co., Oman Construction Co., R. P. Farnsworth & Co. Inc., Wright Contracting Co.**, a joint venture trading as **Midland Constructors**, Columbus, Ohio, for construction of missile launch facilities, *Titan II*, Phase 1, near Little Rock AFB.

$20,000,000—**Eclipse-Pioneer Div., The Bendix Corp.**, Teterboro, for continued manufacture of the inertial guidance system for the *Pershing*. Subcontract from **The Martin Co.**

$5,944,577—**Northrop Corp.'s Radioplane Div.**, Van Nuys, Calif., for production of 770 *RP-76* rocket-powered target missiles.

$2,072,000—**Zarpas-Fullerton**, Pittsburgh, for construction of *Bomarc* facilities at McGuire AFB.

$1,740,170—**R. E. Clarson, Inc.**, St. Petersburg, Fla., for construction of precision trajectory measurement system, Patrick AFB.

$1,274,983—**Land-Air, Inc.**, Chicago, for research and development on range instrumentation at White Sands Missile Range.

$900,000—**Sylvania Electric Products, Inc.'s Electronic Defense Laboratories**, Mountain View, Calif., for development and rapid fabrication of a prototype electronic warfare system.

$3,000,000—**Ford Motor Co.**, Newport Beach, for design and development of combat vehicle weapon system.

$848,690—**Western Electric Co.**, New York City, for research and development of *Nike-Zeus*.

$435,000—**Gulton Industries, Inc.**, Metuchen, N.J., for supplying analog to digital converter systems for use in the *Sergeant* program.

READS DIRECTLY IN POUNDS NO CIRCUIT BALANCING. NO CHARTS. CHOICE OF TENSILE COMPRESSION OR PUSH-PULL.

Designed upon differential transformer principle. Has no internal gears, levers or linkage to bind or wear.

Dillon Load Cells are accurate to within ½ of 1% of full capacity at any point on dial. Non-magnetic. Sensitive to load change of 1/10th of 1% of scale capacity. Tare loads up to 30% can be quickly canceled. Linear dial spacing made possible due to fact that output from Load Cell is in exact linear relation to mechanical displacement.

12 volt DC battery operated model or straight AC model optional. As many as four Load Cells may be used with one Indicator which totalizes individual loads. Minute elongation of Load Cell, even when operating at peak, varies between .002" and .004" depending upon capacity.

Load Cells are fully sealed. Most capacities are of beryllium copper. Can't rust or corrode. Explosion-proof versions can be supplied on order. AN type sockets and plugs used throughout with heavy duty cable.

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27 DIFFERENT CAPACITIES from as low as 0-150 pounds up to as high as 0-200,000 pounds. Variety of connectors such as swivel hooks, cable sockets, threaded studs, etc., available as accessories.

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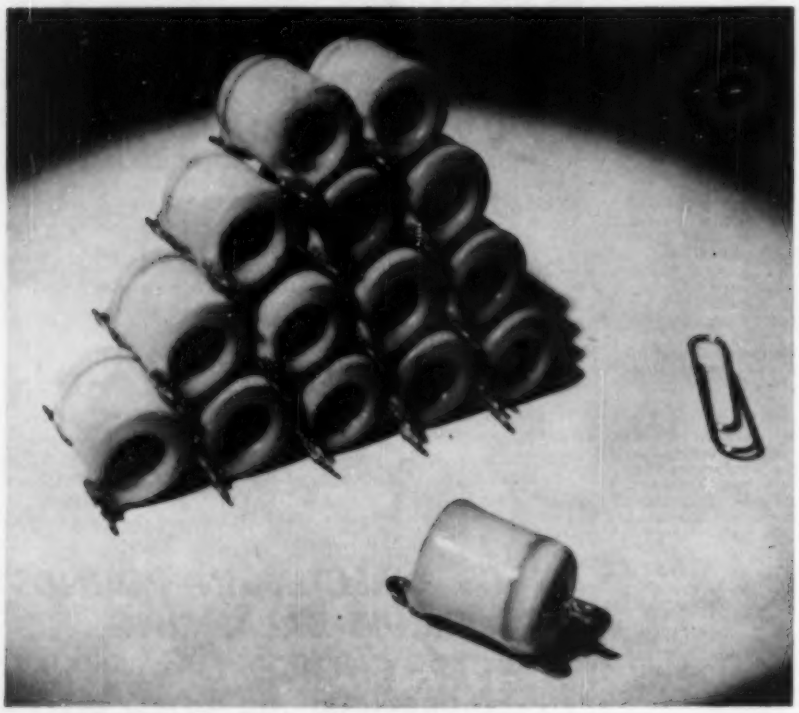
Circle No. 12 on Subscriber Service Card.



Miniature Triggered Spark Gap

A miniature triggered spark gap capable of switching 18 joules of energy at 3000 volts, by remote control, has been developed by the General Electric Power Tube Dept.

The Z-5362 is a gaseous, cold cathode switch tube requiring no warm-up time. When suitably "potted," the brazed ceramic tube can withstand shock of several thousand g's for several milliseconds. It has no delicate parts and can be soldered or welded into a circuit. Operation is unaffected by temperatures from –80 to 200°F

Although it is primarily designed for "one-shot" applications, the tube can be tested both before and after installation, without destroying it.

Circle No. 225 on Subscriber Service Card.

Filaments and Boats

A complete line of tungsten, tantalum and molybdenum filaments and boats are now available in a variety of sizes and shapes from Allen-Jones, Inc. Manufactured for use in high vacuum as an evaporation source, these filaments and boats are stress relieved to obtain the longest possible life in operation, and to maintain their geometry during use.

Circle No. 226 on Subscriber Service Card.

Elapsed Time Indicator

An elapsed time indicator—the MINICHRON—the smallest known indicator of elapsed time, is available from Sela Electronics Co. Its features include no moving parts and infinitestimal current consumption, which makes the miniature unit especially attractive for use with compact and semiconductor circuits.

The MINICHRON is available in voltages of 12 or 115 DC, and 115 AC, with time increments totaling 100, 1000, 5000 or 10,000 hours.

Circle No. 227 on Subscriber Service Card.

High Temperature Oven

A unique Laboratory Furnace introduced by Shampaine Scientific Co. features faster heat up time and greater economy due to addition of recently developed high temperature insulation.

Crystalline properties of new insulation used permit reflection of more than 90% of exposed radiant heat—delivers greater insulating properties than 5-8 in. of conventional firebrick. Reduced size of insulating factor allows increased hot chamber volume in smaller, more compact furnaces.

Heat up time from ambient to 1600° F is 30 minutes or less. Shampaine's new furnace is designed to operate on 50% less wattage than existing furnaces for greater operational economy.

Circle No. 228 on Subscriber Service Card.

Thermocouple Voltmeter

Thermocouples as long as 10,000 feet may be used for temperature indication and control with an all-transistorized instrument announced by Metronix, Inc.

Model 600 is a panel-mounting dc electronic voltmeter especially suitable for monitoring temperatures. It operates on signals that become too small to actuate an ordinary pyrometer after they encounter the resistance of extremely long thermocouples. Designed for circuits requiring high resistance measurements, Model 600 has an input resistance of at least 100,000 ohms —or 2000 times the resistance of an ordinary pyrometer. The signals that actuate the instrument are so small—around half of one ten-millionth of an ampere—that they do not add load to the circuit. The signals are then amplified by the instrument into useful form.

Circle No. 229 on Subscriber Service Card.

Accurate Time Generator

An all-electric digital time generator for system control and synchronization, or for time correlation among diverse data acquisition and logging devices is available from the Information Technology Division of Lockheed Electronics Co. The instrument employs a 1-kc tuning-fork oscillator to assure time-base accuracy of 5 parts in 100,000 for any clocked interval.

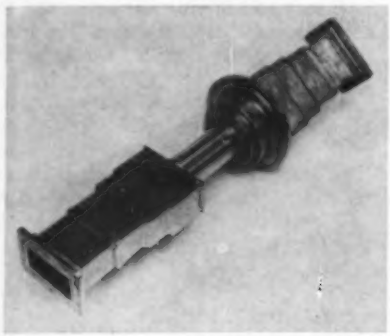
Model 320 yields two sets of outputs. The basic pulse frequency of the tuning-fork oscillator provides timing markers at 0.001-second intervals and, by means of transistor flip-flop dividers, every 0.01, 0.1 and 1 second as well.

Decimal outputs to a total of 23 hours, 59 minutes, 59 seconds are also provided at a rear-panel connector, and are simultaneously displayed on an array of six in-line glow-tube decimal indicators (Nixies).

Circle No. 230 on Subscriber Service Card.

Microwave Rotary Joint

Canoga Corp. offers a high power waveguide Model RJSL-2A of the in-line variety incorporating transitions on each end to convert the TELO mode in the waveguide to the TEM mode in a coaxial line. Non-contacting coaxial



choke joints and ball bearings permit high speed rotation. An O-ring type of pressurizing seal is employed. Operates in a frequency range of 1700 to 1850 mc; VSWR 1.1; power handling capacity 5 megawatts peak, 35 kilowatts average; VSWR WOW .02; insertion loss .02 dbl flanges UG-435A/U.

Circle No. 231 on Subscriber Service Card.

Digital Data System

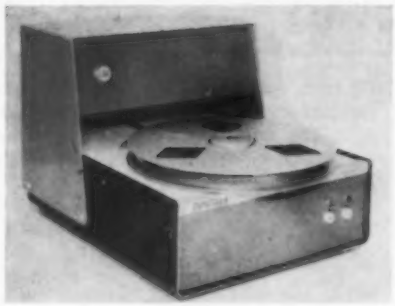
The Communications and Control Corp. has available a digital data system. The 1610 is designed to acquire data at high speed and accuracy with maximal reliability, only solid-state elements such as transistors and diodes are utilized. Accuracies of better than 0.1% are obtainable for periods up to six months without maintenance or calibration. Input analog signals representing pressures, temperatures, voltages, and displacements are digitized and a magnetic tape prepared on-line at a rate of 5000 readings per second or higher. Any number of channels can be prepared in increments of ten channels.

Circle No. 232 on Subscriber Service Card.

Automatic Tape Degausser

An automatic Tape degausser capable of erasing reeled tape to a nominal 90 db below saturation level is available from the DataTape Division of Consolidated Electrodynamics Corp.

Performance of the Type TD-2903 was determined by erasing a prerecorded 15-kc saturated signal and



playing back the residual signal through a filter having a pass band of ±30 cps.

The instrument will accommodate tape widths from ¼-2 in. television tapes on reels from 7 to 14 in. diameter. Both CEC and NARTB reel-hubs may be used. CEC hub adapters are available for use with reels having other dimensions.

Circle No. 233 on Subscriber Service Card.

Lightweight VHF Antenna

A lightweight, low cost air transportable and dual polarized VHF tracking and telemetry antenna, designed for immediate use in missile tracking applications, is available from Avien, Inc.

The VHF tracking and telemetry antenna is known as 420A, and is part of the Series 420 line of antennas. Air transportable, the 420A is lighter, smaller and less expensive than conventional array types of antennas currently in use for missile tracking operations. In addition to providing these advantages, the 420A operates in the standard frequency range of 215-260 mc with a gain of 18 db min. over the band.

Circle No. 234 on Subscriber Service Card.

Transistor Test Socket

A socket for the production testing of 3 or 4 lead transistors is available from Jettron Products Inc. Designed

for 1/8 in. panel mounting in keyed hole and retained by a snap ring, sockets may be mounted on 0.812 in. centers. Double fingered spring contacts grip leads close to base of transistor with frictional force in excess of 50 grams on 0.017 in. diameter lead wires.

Circle No. 235 on Subscriber Service Card.

Low Inductance Capacitor

Axel Electronics is marketing a low inductance capacitor. The unit is identified as 50E104 with a capacitance value of 1.0 mfd. and a voltage rating of 50KV. The capacitor has an internal inductance of 15 millimicrohenries and a ringing frequency of 1.3 megacycles. The capacitor is designed for 100% voltage reversal at 50KV and a life of 10,000 shots minimum. The unit features multi high voltage studs which allows for the use of multi gaps or transmission lines for low external inductance.

Circle No. 236 on Subscriber Service Card.

Pulse Rate Integrator

A meter for measuring frequency deviation is available from Anadex Instruments, Inc.

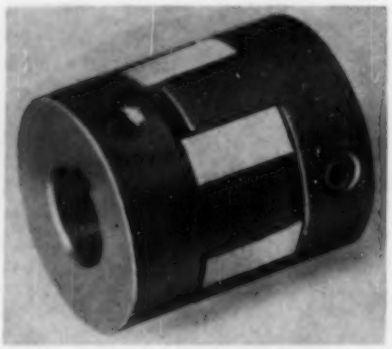
The Series PI-111 Pulse Rate Integrator features an input sensitivity as low as 10 mv rms. Standard models are available to indicate 57 to 63 cps and 380 to 400 cps. Variations are also available with center frequencies from 50 cps to 50 KC. All models feature extreme accuracy, reliability, readability, and 0.1% resolution, states the manufacturer.

Circle No. 237 on Subscriber Service Card.

Flexible Couplings

Stainless Steel and glass-filled du Pont Teflon have been combined to provide a chemical-resistant flexible coupling from Eco Engineering Co. for pumps handling corrosive media.

Serrated coupling halves are precision stainless steel castings. Shock-



cushioning, self-lubricating spider is precision-molded from glass-filled Teflon, which obviates need for external lubrication and also acts as an electronic barrier, preventing the passage of stray currents between driver and pump.

Circle No. 238 on Subscriber Service Card.

Digital Pressure Transducers

Continuous, accurate and reliable monitoring of gas and liquid pipe lines through printed records and warning alarms is possible with a series of digital pressure transducers available from Datex Corp.

Called the DX-100 Series, they indicate in digital form the magnitude of pressure inputs. The output of any transducer is suitable for entry into recording devices such as printers, card punches, tape punches, and light banks.

A typical unit contains an input pressure element, force amplifier, shaft position encoder, motor, power supply, mechanical linkages and terminal strips for electrical connections.

Circle No. 239 on Subscriber Service Card.

Flow Rate Comparator

Simmonds Precision Products, Inc. is marketing a flow rate comparator of laboratory standard quality. Highly precise and accurate, this instrument is designed to compare, calibrate and check accuracy of liquid flowmeters including orifice, rotameter and turbine types. Designed to work with a range of liquid flow rates from 0-800 lb/hr, the basic unit requires an external electronic counter for a time-readout device. The flow rate comparator can be used without removing a flowmeter from its installation.

Circle No. 240 on Subscriber Service Card.

Static Flip-Flop Module

Computer Control Co. is marketing a one megacycle, MIL-T-Series of plug-in digital modules.

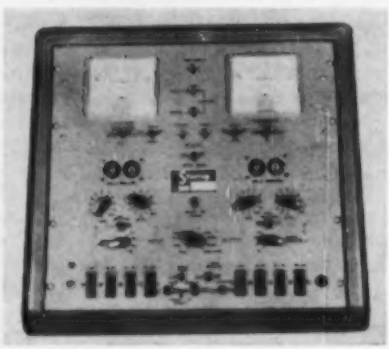
The Model FS-20 operates within a temperature range of 0° C. to 65° C. This exceeds MIL-E-16400, Class 4. It has a humidity maximum of 95% and fulfills MIL-T-17113 requirements for shock and MIL-STD-167, Type 1 for vibration. The static flip-flop contains 2 independent circuits plus comprehensive diode gating.

Circle No. 241 on Subscriber Service Card.

Cable Insulation Tester

Sturrup, Inc. has introduced an economical cable and system tester.

The equipment will test 101 circuits at the rate of 30 conductors per second. Each wire of the input circuit is individually checked to ground and to every wire of the output circuit. This allows the testing of branched cables or system units where one wire may lead to several different places.



Circle No. 242 on Subscriber Service Card.

Sheet Surfacer

Sheet surfacing operations ranging from cleaning and preparing metals for drawing to graining and polishing practically any sheet material can be done fast and efficiently on the TRI-MATIC Oscillating Sheet Surfacer available from Sales Service Mfg. Co.

The machine employs abrasive impregnated nylon mounted on an oscillating arbor which is adjustable to oscillate from 0 to 400 times per minute. The workhead drive can be equipped for single or variable speed and the feed rolls are equipped with variable speed drive. The work pressure is positively controlled and electrically metered to make it easy to maintain a constant pressure as the workhead wears and to repeat set-ups accurately.

Circle No. 243 on Subscriber Service Card.

Thermocouple Calibration

B. & F. Instruments, Inc. is marketing a calibrator to aid in accurately recording dynamic temperature variations. For optimum accuracy while using multi-channel recording oscillographs for dynamic temperatures, it is necessary to calibrate out errors due to the loss in the input cabling. The temperature calibrator, with its own power supply does this by offering automatic 4-step calibration simultaneous or sequential; calibration sets scale for direct reading of temperature into low impedance balvanometer regardless of input lead length or resistance and it accommodates all thermocouples with their reference junctions.

Circle No. 244 on Subscriber Service Card.

Video Logarithmic Amplifier

A fully transistorized logarithmic video amplifier LVT-2 is available from the W. L. Maxson Corp. When used in conjunction with a crystal detector mount, results in a crystal video receiver with a logarithmic input-output relationship. A 60 db dynamic range is achieved, with a bandwidth of 4 mc. Individual stage feedback permits shaping of transfer characteristic. Amplifier pairs matched to within ±1.5 db can be supplied as a special item.

Circle No. 245 on Subscriber Service Card.

Repetitive Curve Follower

It is only necessary to plot a repetitive function variation once with the Data-Trak curve follower available from Research, Inc. Continuous rotation of the data drums in the new models produces cyclical output signal variations from a pencil drawn "pattern".

Model FGE 5048 Data-Trak interprets function curves drawn as a double line with ordinary pencil on common graph paper. No special paper, pencils, or conductive inks are required.

Circle No. 246 on Subscriber Service Card.

Pressure Intensifier

A pressure intensifier with a 15,000 psi rating and an output-input pressure ratio of 9 has been developed by Ruska Instrument Corp.

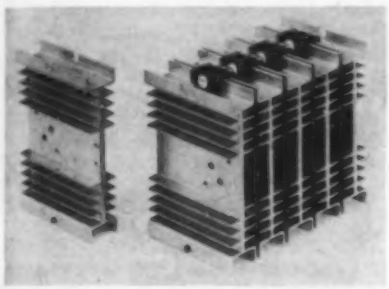
The unit is machined from stainless steel for maximum resistance to corrosion and wear. Its single-barrel construction insures precise positioning of

low-pressure and high-pressure chambers, thus minimizing war and coupling problems. Each cylinder is precision bored and honed along the barrel center line to reduce wear on compression rings by making the piston areas highly concentric. Multiple Teflon packings provide friction-free operation and long life in applications that prohibit lubrication.

Circle No. 247 on Subscriber Service Card.

Transistor Heat Sinks

Heat Sinks for power transistors and diodes, are available from Invar Electronics Corp. Offering 25 sq. in. of surface area for each inch of length,



these heat sinks provide a large heat dissipating surface while maintaining a minimum overall size. The units were specifically designed to be used singly or in multiple heat sink arrays and are furnished with holes for mounting the power transistor, for mounting or "stacking" the heat sinks in a compact array, and for attaching a terminal or resistor board to the heat sink..

Circle No. 248 on Subscriber Service Card.

Solid State Ring Counter

A miniature size, fast counting solid state ring counter is available from Tempo Instrument Inc. Capable of a counting rate up to 150,000 cps, (or up to 1,000,000 cps on special-order types) the unit is extremely reliable . . . guaranteed not to miss a count regardless of frequency, forward, backward, or intermittent switching. The circuit design employs dc logic for coupling the trigger signals to the counting circuits.

Circle No. 249 on Subscriber Service Card.

Microwave Amplifiers

Microwave Electronics Corp. has in production a Ku-band solenoid-focused traveling-wave amplifier. The power output rating is 1 watt minimum, but the tubes have shown test capabilities up to 6 watts output in the center of the frequency band. The standard frequency range is 12 to 18 kmc with a minimum small signal gain of 30 db. The small signal gain variation over the band is less than 8 db.

Circle No. 250 on Subscriber Service Card.

new literature

POWER CONVERSION — Hamilton Standard's Electronics Dept. has published a 16-page static power conversion guide which explains this field of controlled electrical power. The booklet outlines the advantages of static power equipment and provides useful comparisons between static and rotating electrical devices.

Circle No. 200 on Subscriber Service Card.

OIL FEED CONTROL—Complete details on three types of a "Circulube" automatic lubricating system which provides positive control of oil feed and circulation rates are described in a bulletin available from the Bijur Lubricating Corp. Designated "CL," this bulletin includes both photographs and engineering drawings to illustrate product data and specifications.

Circle No. 201 on Subscriber Service Card.

QUENCH OIL INDICATOR—Bulletin WS-60 available from Ipsen Industries, Inc. describes the installation and operation of the Ipsen Water Sentinel, a safety device that detects water in enclosed type oil quench tanks. Information includes several illustrations that show the components of the water sentinel as well as the installation of the unit. A graph shows response time for different water contamination levels of quenching oil.

Circle No. 202 on Subscriber Service Card.

CONTROL SYSTEM—A 12-page brochure which describes the FultroMatic control system is available from Robertshaw-Fulton Controls Co. The sales folder, numbered SF-755-A, contains a description of the basic control instrument, as well as the various means of measurement which can be employed with it. Information is also provided on FultroMatic with reset.

Circle No. 203 on Subscriber Service Card.

SERVO AMPLIFIERS—Magnetic Amplifiers Division of The Siegler Corp. has made available a 16 page color illustrated catalog (S-1169) comprising the major products of its servo amplifier line for both military and industrial applications. The catalog is comprehensive and includes specifications and application data for push-pull saturable transformers, all magnetic and transistor magnetic amplifiers, miniaturized amplifiers plus its line of transistor servo amplifiers.

Circle No. 204 on Subscriber Service Card.

CHROMATOGRAPHY—The 5th Edition of the Shandon Chromatography Catalogue describes unique equipment not available in the U.S. before. Among these are a 20 inch two-dimensional chromatography tank; a multi-sheet chromatography tank which enables up to 50 one-way or 5 two-way chromatograms to be run simultaneously; and numerous related equipment.

Circle No. 205 on Subscriber Service Card.

ZENER PROTECTION CIRCUITS—A 4-page application note on Zener Protection Circuits for aircraft voltage surges is available from Motorola Semiconductor Products Div. The note includes circuit schematics, performance curves, and a nomograph showing quantity of zeners needed. A total of 8 illustrations supplement the text.

Circle No. 206 on Subscriber Service Card.

ORDNANCE DEVICES — Explosive-actuated devices are described in a catalog by Lockheed Electronics Co. Included in the folder are specification sheets describing a cartridge type pin-puller; an explosive rotary disconnect for remote separation of pygmy connectors; a helium dump valve; a safe and arm initiator for high-explosive systems; and a cartridge-actuated disconnect adapter for remote operations.

Circle No. 207 on Subscriber Service Card.

TRANSFORMER CATALOG—A catalog, listing latest miniature transformer information, diagrams and detailed specifications is available from Microtran Company, Inc. Typical special transformers, designed and manufactured to exacting customer specifications, are listed. Also Microtan Miniature Transformers for Electronics, Electrical, Aircraft and Missile applications—designed to meet MIL-T-27A and other military specifications.

Circle No. 208 on Subscriber Service Card.

CHRONOGRAPHS—Gaertner Scientific Corp. has published a bulletin containing complete descriptive and technical data on its line of tape chronographs, drum chronographs and precision regulator clocks. The 8-page brochure shows photographs of the equipment, provides technical information on its operation, and lists catalog numbers for all standard models, accessories, and supplies.

Circle No. 209 on Subscriber Service Card.

DYNAMIC FOCUS COIL—A bulletin which gives dimensional drawing, electrical data tables and complete description of Type F40 dynamic focus coil which provides exceptionally sharp overall focusing for 1½ in. neck diameter flat faced large angle cathode ray tubes used in high resolution applications is available from Syntronic Instruments.

Circle No. 210 on Subscriber Service Card.

letters

F.A.I.'s Impartiality

To the Editor:

I am in receipt of a copy of a letter sent to MISSILES AND ROCKETS by Mr. H. R. Gillman, Director General of the Fédération Aéronautique Internationale (M/R, Dec. 12, p. 6). The letter expressed considerable concern over the story that appeared in M/R Nov. 21 entitled "F.A.I. Rules Put Russians on Spot."

We have read the story carefully and are in complete agreement with Mr. Gillman.

As you know, NAA is the United States representative of F.A.I. and has been the sole U.S. representative since 1922. NAA has actively participated in the discussion and approval of many F.A.I. rules and regulations that apply to World and World-Class Record attempts. Since assuming the position of Executive Director of NAA on Nov. 1, 1960, I have spent considerable time reviewing the policies, procedures and work of the F.A.I. I have been completely amazed to learn that F.A.I. provides probably the only international conference table that is actually working at the present time. By this I mean that it is the only medium that I know of where representatives of both free and Iron Curtain countries sit down at a conference table and discuss and approve or disapprove rules and regulations governing all types of World and World-Class Records, and then all of the nations involved live by these rules and regulations to the letter.

All F.A.I. rules and regulations apply to all F.A.I. member nations. No rule or regulation favors one country over another, nor gives one country an advantage over the other.

For your information, all World and World-Class Records are on file at F.A.I. Headquarters in Paris, and these records are open for inspection by all member nations of F.A.I. This means that the USA can inspect USSR record claims and the USSR can inspect USA record claims.

In order to establish official World and World-Class Records in any nation, that nation must abide by the rules, whether it be the USA or USSR. No intention of breaking "secrecy barriers" is implied or practiced.

We would like to clarify one important point. Before a record is attempted, the National Aero Club of the country in which the record is to be attempted sanctions the attempt. However, this advance sanctioning merely puts the attempt on record and blocks a period of time during which no one else in that country may attempt this record. F.A.I. is not involved in sanctioning at all. F.A.I. comes into the picture only after a record has been attempted and a dossier is sent to F.A.I. Headquarters in support of a claim of a new World or World-Class Record. Therefore, there is no way that there could be a breach of security before a record attempt is made.

At the F.A.I. General Conference in Barcelona in October, a recommendation was made that a nation should file the details on its record attempt *prior* to the attempt. However, this was voted down by the delegates, and the policy remains that the details are not filed until *after* the attempt has been made and the claim to a new record is forwarded.

In order to certify a record, no country is able to "balk before complying" to F.A.I. rules. Since these rules are developed in Committee, there is no need for a nation to "capitulate," nor are "unofficial records" considered to be "cheating or exaggerating." All record claims that are certified and registered by F.A.I. are based on accuracy, proved beyond a shadow of a doubt through instrumentation, certified observers and certified statements. All of which are, as I mentioned above, open for inspection by all member nations. F.A.I. gives no thought as to whether a nation is "neutral and non-committed."

It gives us considerable concern in NAA when inaccurate statements or innuendoes are made regarding the work of the F.A.I. I believe that you will find that the F.A.I. records are of the same high quality and accuracy since its formation in 1905 and are beyond dispute. We hope that your publication will be guided by this record in its future coverage of F.A.I.

Ralph V. Whitener
Executive Director
National Aeronautic Association
Washington, D.C.

ARS Reporting

To the Editor:

May I thank you for your splendid report on the recent national ARS meeting in M/R Dec. 12, and especially for your writeup "All-Solid Craft Urged for Moon Trip" on page 35, describing my proposed all-solid space launcher.

You did an outstanding job of technical reporting, and all of us here appreciate your general coverage.

H. L. Thackwell, Jr.
Senior Vice President
Grand Central Rocket Co.
Redlands, Calif.

Mercury Viewports

To the Editor:

May I expand on your report in M/R, Jan. 2, about the viewports on the *Mercury* spacecraft that was flown Dec. 19? The report mentioned damage and said that the windows consisted of three or four layers of glass.

Each viewport on this capsule consisted of five panels. They are not laminated. The outer three panels, made of 96% silica glass (Vycor), served as heat shields. The inner two panels, made of strengthened aluminosilicate glass, were designed to meet a double fail-safe requirement to protect the integrity of the enclosure. Since the outer panels were designed to survive launch forces and reentry temperatures only, we were not concerned that one, two or all three of these outer panels might break from the impact of landing. In fact, the frame was designed for this possibility. Since only the outermost panel on one viewport broke on Dec. 19, we are satisfied that the viewports functioned exactly as designed.

I might mention that a later viewport design, trapezoidal in shape rather than circular, consists of four panels—two heat-shielding Vycor panels and two strengthened aluminosilicate panels. The purpose of this design is to provide more viewing area. Some *Mercury* spacecraft already are equipped with the new viewports.

A. F. Shoemaker
Product Development Coordinator
Aircraft & Missiles Group
New Product Division
Corning Glass Works
Corning, N. Y.

Interest in Energy Chart

In the Oct. 3 M/R was a chart entitled "The Energy Level of Things."

Next week our course in physics will cover this subject and such a chart would be extremely beneficial. If possible, please send to me 12 copies.

James B. Campbell
Lt. Colonel, Arty.
Associate Prof. of Physics
United States Military Academy
West Point, N. Y.

Please send me one copy of "The Energy Level of Things."

M. Speweck, Section Mgr.
Materials Laboratories
Westinghouse Electric Corp.
East Pittsburgh, Pa.

Please send me two reprints of "The Energy Level of Things."

Ralph H. McAllister, Eng.
Designer
ANP Dept., General Electric Co.
Cincinnati

I have read with great interest the chart entitled "The Energy Level of Things" by J. R. Williams. If reprints are available, I would appreciate your sending one to me.

Samuel Bousky, Chief Scientist
Chicago Aerial Industries
Barrington, Ill.

The chart was authored by Jean R. Williams, of the Air Force Special Weapons Center (ARDC), Kirtland AFB, N.M., and made available to M/R by the Air Force Office of Scientific Research. Reprints may be obtained free of charge by writing to this magazine.—Ed.

when and where

JANUARY

American Astronautical Society, Annual Meeting, Sheraton-Dallas Hotel, Dallas, Texas, Jan. 16-18.

Lectures in Aerospace Medicine, School of Aviation Medicine, Brooks AFB, Texas, Jan. 16-20.

Winter Instrument-Automation Conference & Exhibit, Instrument Society of America, Jefferson Hotel and Kiel Auditorium, St. Louis, Mo., Jan. 17-19.

Institute of the Aeronautical Sciences 29th Annual Meeting, Hotel Astor, New York, **(Honors Night Dinner** Jan. 24) Jan. 23-25.

1961 Plant Maintenance & Engineering Conference, International Amphitheatre, Chicago, Jan. 23-26.

American Mathematical Society, National Meeting, Willard Hotel, Washington, D.C., Jan. 24-27.

Society of Plastics Engineers, Annual Technical Meeting, Shoreham and Sheraton-Park Hotels, Washington, D.C., Jan. 24-27.

American Institute of Electrical Engineers, Winter General Meeting, New York, N.Y., Jan. 29-Feb. 3.

American Society for Testing Materials, Committee Week, Netherland Hilton Hotel, Cincinnati, Ohio, Jan. 30-Feb. 2.

American Physical Society, New Yorker Hotel, N.Y.C., Jan. 31-Feb. 4.

FEBRUARY

Institute of Radio Engineer, PGMIL, Los Angeles, Calif., Feb. 1-3.

American Rocket Society, Solid Propellant Rocket Conference, The Hotel Utah, Salt Lake City, Feb. 1-3.

Second Annual Symposium on Nondestructive Testing of Aircraft and Missile Components (unclassified), South Texas Section of SNT and Southwest Research Institute, Gunter Hotel, San Antonio, Feb. 14-16.

Institute of Radio Engineers, International Solid-State Circuits Conference, 8th Annual Meeting, Sheraton Hotel, and University of Pennsylvania, Philadelphia, Feb. 15-17.

American Society for Metals, Albuquerque and Los Alamos Chapters, Recent Developments in Materials for Nuclear Applications, University of New Mexico, Albuquerque, Feb. 16-17.

American Institute of Mining, Metallurgical and Petroleum Engineers, Annual Meeting, St. Louis, Feb. 19-23.

Pacific Electronic Trade Show, Great Western Exhibit Center, Los Angeles, Feb. 26-Mar. 1.

American Institute of Chemical Engineers, National Meeting, Roosevelt Hotel, New Orleans, La., Feb. 26-Mar. 1.

Association of Iron and Steel Engineers, Los Angeles, Calif., Feb. 28-Mar. 2.

Western Joint Computer Conference, Los Angeles, Feb. 28-Mar. 1.

MARCH

Optical Society of America, Roosevelt Hotel, Pittsburgh, Mar. 2-4.

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Paris, France—11 Rue Condorcet; TRU 15-39

Frankfurt/Main, West Germany—Friedrich-Ebert-Anlage 3

Gas Turbine Conference and Exhibit, sponsored by Gas Turbine Power Division of American Society of Mechanical Engineers and U.S. Department of Defense, Shoreham Hotel, Washington, D.C., Mar. 5-9.

reviews

PERCHLORATES, ACS Monograph No. 146, edited by J. C. Schumacher, Reinhold Publishing Corp., N.Y., 257 pp., $8.75.

The author developed the material from the point of view of the manufacturer interested primarily in finding and developing novel, economical and safe methods of manufacture, handling and use of the perchlorates and perchloric acid.

An entire chapter is devoted to the growing use of perchlorates in the explosives and propellants areas. Safety considerations are extensively treated.

TOXICITY AND PERSONAL DECONTAMINATION OF BORON HYDRIDE PROPELLANT FUELS, S. Rothberg and others. Order PB 161772 from Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C. 16 pp., $.50.

A mild ammonia solution proved effective as a flushing agent in removing toxic boron hydride fuels from the skin of test animals. The experiment was conducted as part of an Army study of the toxic effects of boron hydride propellant fuels and the value of various decontamination measures.

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EMPLOYMENT

MECHANICAL ENGINEER

Amcel Propulsion Inc., a growing organization located in a mountain resort area, has an opening for a mechanical engineer preferably with 3 to 5 years experience of design and prototype follow through of explosive actuating or gas generating.

Write or call Dr. L. R. Rothstein

AMCEL PROPULSION INC.
P. O. Box 3049 **ALpine 3-6464**
Asheville, N. C.
A subsidiary of Celanese Corporation of America

editorial . . .

On Nuclear Power and Safety

IF THE UNITED STATES is to compete successfully in space exploration, with its power-hungry technical requirements, the development of nuclear energy into rocket propulsion is completely and inevitably necessary.

There is evidence, however, that the fears of radioactive contamination reflected in world opinion are holding back an active development and testing program without real cause.

There is a danger of contamination, of course. There probably always will be, where nuclear power is used. But the fears—and they do create a political force—are frequently vague surmises formed with little real basis in fact.

Lt. Col. Joseph A. Connor, Jr., a USAF medical officer and chairman of the Aerospace Nuclear Safety Board of the AEC, attacks some of these current fears or misapprehensions in a paper delivered recently in San Francisco.

Examining the U.S. nuclear propulsion projects, SNAP and ROVER, Col. Connor has considered their safety factors in considerable detail. This includes protection of crews and of the public; selection of ranges and re-entry burnout, launch pad failures and contamination of the upper atmosphere.

He points out that the AEC's Aircraft Nuclear Propulsion Office has spent $4 million in intensive and long-term studies of the patterns and possibilities of radiation resulting from nuclear accidents. A comparable amount has been spent on studies of shielding.

In making these studies and tests, the worst theoretical accidents have been studied.

Appraisal of the radiation risks, says Col. Connor, "reveals them to be no more than those risks encountered in the progressive development of steam and electric power, the airplane, the automobile or the rocket.

"Just as the uses of the older forms of energy have been governed by considerations of safety, so will the ultimate role of nuclear energy in space be largely determined by its safety.

"The conclusion reached is that the use of nuclear-powered devices sufficient to meet all space requirements expected to be developed by 1980 would release but a small fraction of the radioactivity considered by the Federal Radiation Council Guides to be tolerable for the general population."

(Just for effect—compare a possible mishap with a SNAP 8 generating 30 electrical kilowatts with the explosion of a multiple megaton atomic bomb on the Nevada or Sahara deserts).

THE FACT IS—again—that nuclear energy is an inevitable part of space exploration technology.

The advantages of nuclear power bring with them a price that man must pay. He either pays it by absorbing unacceptable amounts of ionizing radiation or he provides for safety, accepting what handicaps this may bring.

The AEC Nuclear Safety Board obviously believes the safety requirements can be met, both for the crews who operate the devices and for the public at large.

It will take more than one report to convince the world. If we wait until the world is convinced we are very apt to be far behind other nations who may not be so considerate. We should get on with the program. In the final analysis the real proof will come only with the doing.

Clarke Newlon

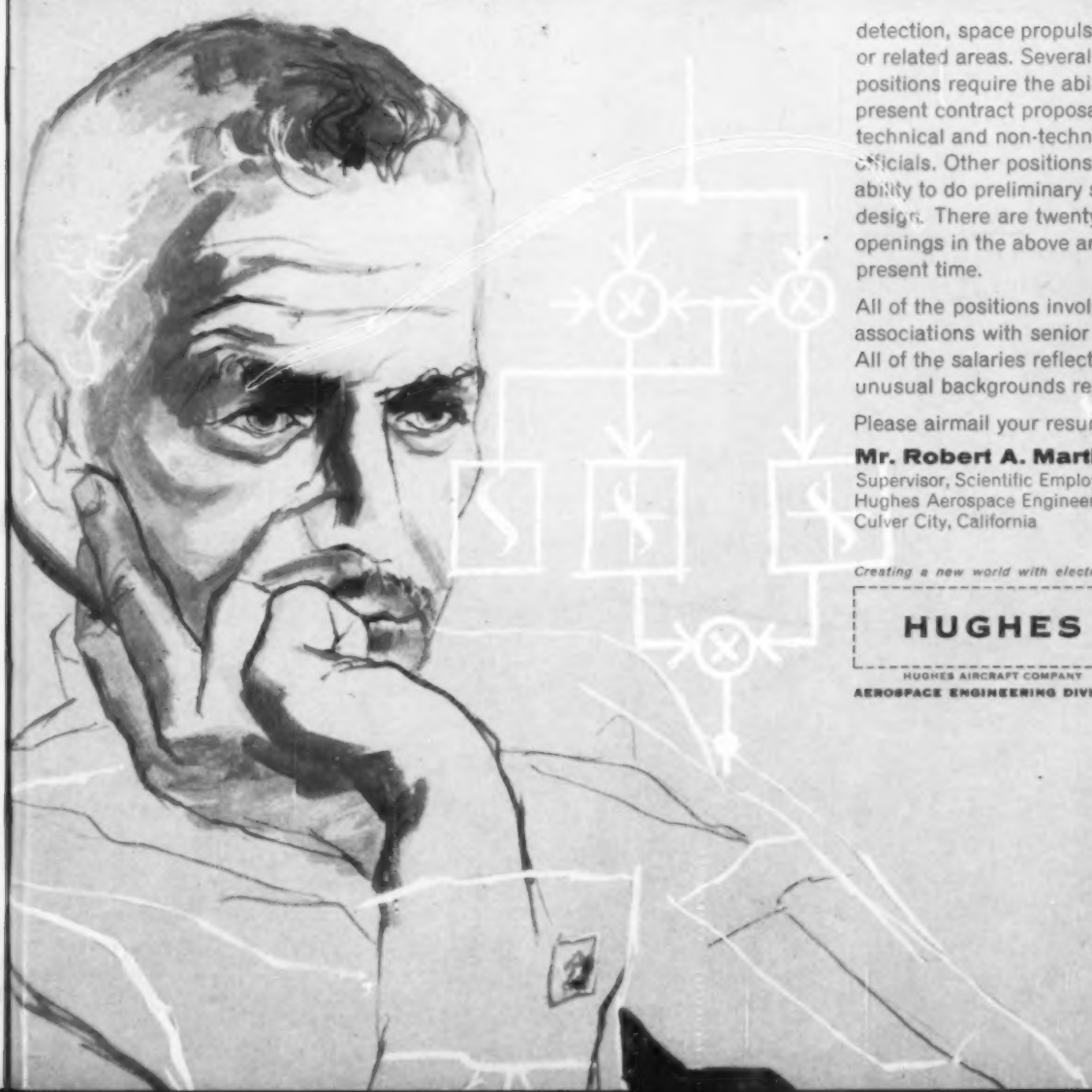
We promise you a reply within one week

The complexity of modern technology...the rapid increase in the number of specializations...and the frequent shifts in technological emphasis all have combined to require a staff of alert, aggressive, creative teams of engineering specialists. Their responsibility is to assist management in the formulation of plans for future efforts.

For our purposes the teams should be staffed by graduate Electronic Engineers and Physicists who have acquired several years of experience with radar, guided missiles, computers, infrared detection, nuclear radiation equipment, micro-electronics, underwater

pportunities in:

xploratory Studies · Advanced Planning · Systems Analysis



detection, space propulsion systems or related areas. Several of the positions require the ability to present contract proposals to both technical and non-technical officials. Other positions require the ability to do preliminary systems design. There are twenty-three openings in the above areas at the present time.

All of the positions involve close associations with senior engineers. All of the salaries reflect the unusual backgrounds required.

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Mr. Robert A. Martin
Supervisor, Scientific Employment
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Bell-powered Agena satellites in orbit — symbolized.

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This Bell engine now has re-start capability — the first in the nation. This means that its satellite can change orbit **in space** without the penalty of extra engines. Presently in production, this engine also is adaptable to new fuels and new assignments and, consequently, is programmed for important military and peaceful space ventures of the future.

Agena's engine is typical of the exciting projects in Bell's rocket propulsion center. It is part of the dynamic new approach of a company that's forging ahead in rocketry, avionics and space techniques. These skills serve all government agencies. Engineers and scientists anxious for a new kind of personal challenge can find it at Bell.

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